PHILCO **SERVICE**

WORLD-WIDE WITH THE ARMED FORCES

PHILCO TRAINING MANUAL for

RADIO TRANSMITTERS

BC-640-A
AND
BC-640-B

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ANSWER SHEET FOR RADIO TRANSMITTERS BC-640-A AND BC-640-B

EXAMINATION NO. 1, PART I

1. The effective coverage between an aircraft at 10,000 feet and ground is 155 miles.

2. 100 to 156 megacycles.

3. Transmitter power, receiver sensitivity, antenna height, orientation, and location.

4. The eight major physical units of the BC-640-B equipment are:
    Amplifier Panel PN-8-B.
    Oscillator Panel PN-9-B.
    Modulator Panel PN-10-B.
    Control Panel PN-11-A.
    Power-Supply Panel PN-12-A (2).
    Power Control Panel PN-13-B.
    Power Input Transformer.
    Cabinet CS-88-A.

5. Step up the line input voltage from 110 to 220 volts when 110 volts is supplied.

6. To regulate the line input voltage and produce a constant output of 230 volts, a. c.

7. The lower power-supply panel supplies the r-f circuits in the oscillator and amplifier panels. The upper power-supply panel supplies the a-f circuits in the modulator panel.

8. A zero-bias class-B modulator is used.

9. Frequency stability.

10. Over-driven class-C r-f amplifiers.

11. d.
12. d.
13. c.
14. c.
15. a.
16. b.
17. c.
18. b.
19. a.
20. c.

EXAMINATION NO. 1, PART II

1. c.
2. b.
3. c.
4. d.
5. a.
6. b.
7. a.
8. c.
9. b.
10. a.

FINAL EXAMINATION, PART I

1. a.
2. c.
3. d.
4. b.
5. a.
6. b.
7. c.

8. The power control circuits fuse the line input voltage and provide a means, through switch and relay action, of distributing an adjustable load voltage to the various circuits of the equipment.

9. From the 24-volt selenium-rectifier circuit located on the control panel.

10. Class-A voltage amplifier.

11. The type of speech input does not affect the amplitude of the audio signal reaching the driver stage since the local input is attenuated by series resistors, and the remote input by the remoting lines, thereby providing a relatively level input.

12. Determines the magnitude of the oscillations.

13. The audio oscillator is used to supply a 1000-cycle tone for m-c-w operation.

14. From a selenium rectifier which is tapped from the filament supply to the audio-oscillator tube.

15. 230 volts, a. c.

16. 24, 315, 395, and 800 volts.

17. 24 volts, d. c.

18. No circuits of the equipment can be energized.

19. Inductive coupling.

20. To complete the circuits to ground when the d-c meter circuits are disconnected.

21. The M. A. CURRENT meter when the METER RANGE MILLIAMPERES switch is set to the MOD. position.

22. Volume control 53.

23. The M. A. CURRENT meter provides a relative indication of the transmitter output when the METER RANGE MILLIAMPERES switch is set to the PA-G position, and the G1-G2-MON. switch is set to the MON. position.

24. To protect the various vacuum tubes from overload due to excessive plate and grid currents.

25. If the T2 dial is not within 15 dial divisions of the CO/T1 dial, the 2nd tripler is tuned to the wrong harmonic.

FINAL EXAMINATION, PART II

1. c.
2. c.
3. a.
4. d.
5. b.
6. a.
7. d.
8. c.
9. b.
10. Test points ①, ②, E, and E1.

TROUBLE-SHOOTING SUPPLEMENT FOR RADIO TRANSMITTERS BC-640-A AND BC-640-B

NOTE: When insulating any of the high-voltage leads, use an insulating material sufficiently heavy to avoid high-voltage breakdowns.

EXPERIMENT NO. 3

1. Remove plate lead from coil 178 by loosening hexagonal nut. Insulate solder lug and replace lead. This will simulate an open plate-tank coil.

2. Remove lead from terminal 3 on filament transformer 196. Insulate solder lug and replace lead. This will simulate an open filament circuit.

EXPERIMENT NO. 4

1. Replace VT100 with a defective tube, or insulate pin number 4 on bottom of tube to simulate a defective tube.

2. Remove resistor 192-1 from fuse clip holders. Insulate one end of resistor and replace in clips. This will simulate an open cathode-bias resistor.

3. Insulate grid lead of capacitor 166-3 to simulate an open plate blocking capacitor.

4. Remove lead from terminal 9 on filament transformer 196. Insulate solder lug and replace lead. This will simulate an open meter resistor, 189-4.

EXPERIMENT NO. 5

1. Replace VT204 with a defective tube, or insulate grid lead to simulate a defective tube.

2. Remove plate lead from neutralizing-link socket under chassis by loosening hexagonal nut. Conceal lead in chassis wiring. This will simulate an open in the plate-supply circuit.

3. Remove lead to resistor 194-1 and capacitor 169-6 by loosening hexagonal nut under chassis. Insulate solder lug and replace lead. This will simulate an open grid circuit.

EXPERIMENT NO. 6

1. Remove jumper which connects terminal 17 to neutralizing plug under chassis. This will simulate an open in the plate-voltage supply.

2. Remove either lead from rear of meter 139. Insulate solder lug and replace lead. This will simulate a defective meter.

3. Replace either or both VT204's with gassy or defective tubes.

4. Remove lead from terminal 1 on filament transformer 146. Insulate solder lug and replace lead. This will simulate an open primary winding of transformer.

EXPERIMENT NO. 7

1. Remove lead from terminal 17 on rear of modulator panel. Insulate solder lug and replace lead. This will simulate defective interpanel wiring.

2. Insulate contacts on microphone jack 41 to simulate a defective jack.

3. Loosen hexagonal nut on terminal 3 of microphone transformer, and remove lead. Insulate solder lug and replace lead. This will simulate an open primary winding.

4. Connect a jumper between two pins of potentiometer 53. This will simulate a defective volume control.

5. Remove resistor 51 from fuse clips. Insulate one end of resistor and replace in clips. This will simulate an open cathode-bias resistor.

6. Remove any one of the leads to the primary winding of modulation transformer 59. Insulate solder lug and replace lead. This will simulate an open primary winding of the transformer.

EXPERIMENT NO. 8

1. Insulate the contacts of relay 42 to simulate faulty relay action.

2. Connect a jumper between pins 5 and 8 on tube socket. This will simulate a short within the tube.

EXPERIMENT NO. 9

1. Remove lead from terminal 1 on choke 94-1 by loosening hexagonal nut. Insulate solder lug and replace lead. This will simulate an open choke.

2. Remove resistor 96 from fuse clips. Insulate one end of resistor and replace in clips. This will simulate an open dropping resistor.

3. Remove any one of the four rectifier tubes. Insulate pin number 1 and replace tube in socket. This will simulate an open filament circuit in the tube.

4. Remove lead from either terminal 2 or 3 on transformer 98. Insulate solder lug and replace lead. This will simulate an open primary winding.

EXPERIMENT NO. 10

1. Remove either lead from meter 113. Insulate the solder lug and replace lead. This will simulate a defective meter.

2. Remove lead from terminal 6 on rear of power control panel. Insulate solder lug and replace lead. This will simulate defective interpanel wiring.

3. Remove any one of the leads from any of the four tumbler switches under the cover on the front of the control panel. Insulate the solder lug and replace lead. This will simulate a defective switch.

4. Remove any one of the leads from the rear of relay 6 and conceal lead behind unit. This will simulate a defective plate-contactor relay.

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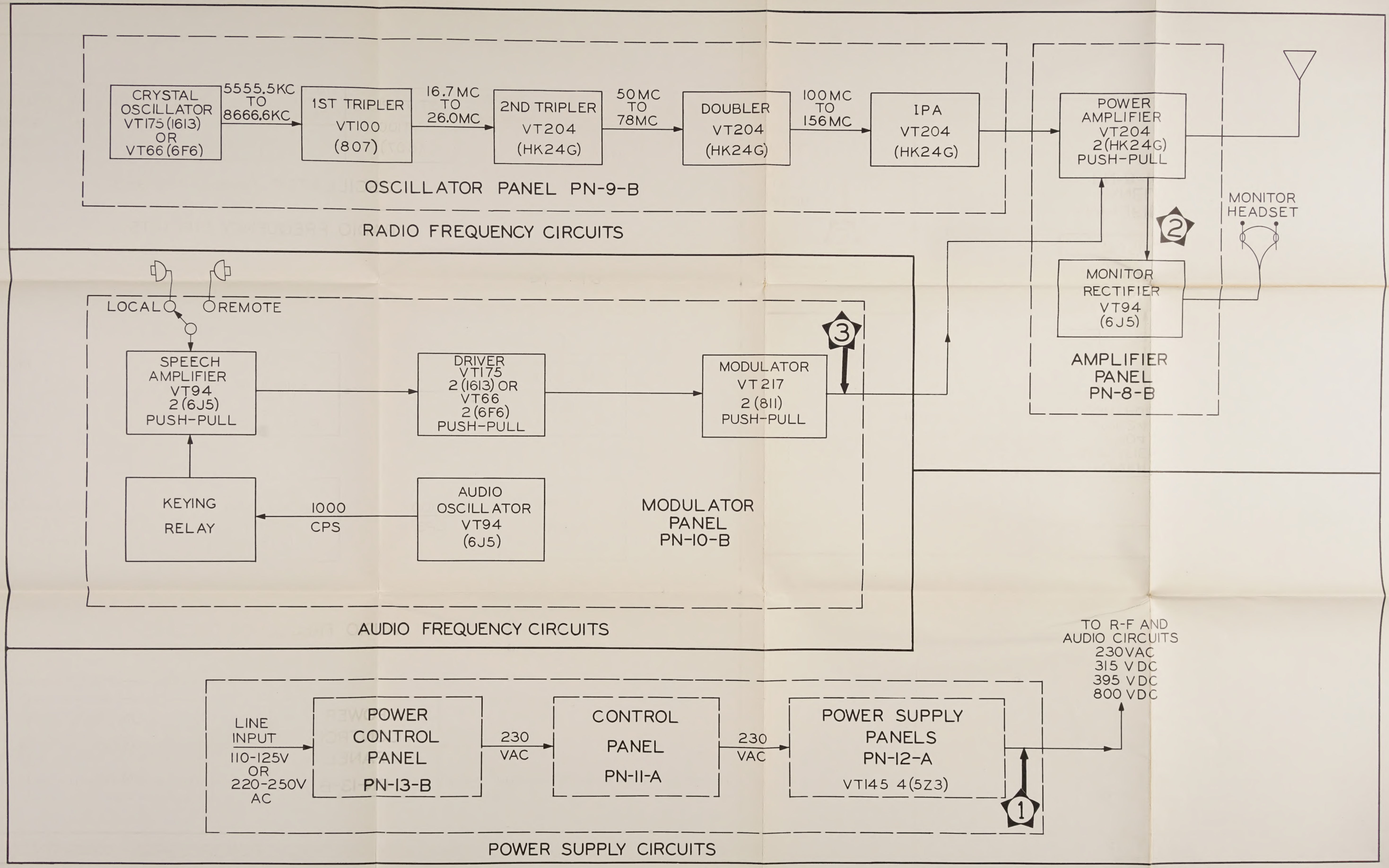
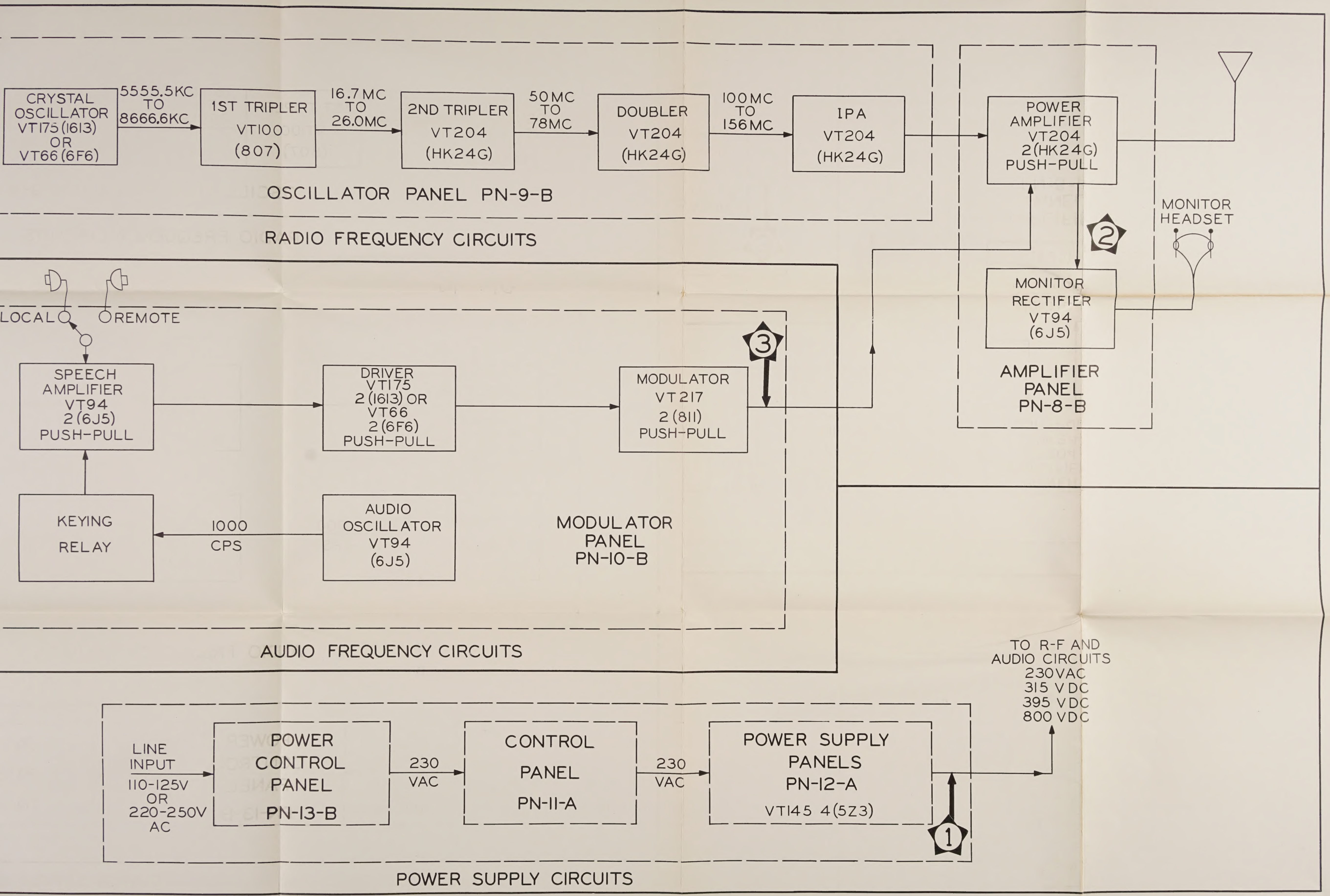
WALL CHART
No. 1

Functional Block Diagram
of Radio Transmitters
BC-640-A and BC-640-B


CRYSTAL OSCILLATOR VT175 (1613) OR VT66 (6F6)
5555.5KC TO 8666.6KC
1ST TRIPLER VT100 (807)
16.7MC TO 26.0MC
2ND TRIPLER VT204 (HK24G)
50MC TO 78MC
DOUBLER VT204 (HK24G)
100MC TO 156MC
IPA VT204 (HK24G)
OSCILLATOR PANEL PN-9-B
RADIO FREQUENCY CIRCUITS
POWER AMPLIFIER VT204 2(HK24G) PUSH-PULL
②
MONITOR RECTIFIER VT94 (6J5)
MONITOR HEADSET
AMPLIFIER PANEL PN-8-B
LOCAL
REMOTE
SPEECH AMPLIFIER VT94 2(6J5) PUSH-PULL
DRIVER VT175 2(1613) OR VT66 2(6F6) PUSH-PULL
MODULATOR VT217 2(811) PUSH-PULL
③
KEYING RELAY
1000 CPS
AUDIO OSCILLATOR VT94 (6J5)
MODULATOR PANEL PN-10-B
AUDIO FREQUENCY CIRCUITS
TO R-F AND AUDIO CIRCUITS
230VAC
315 VDC
395 VDC
800 VDC
LINE INPUT
110-125V OR 220-250V AC
POWER CONTROL PANEL PN-13-B
230 VAC
CONTROL PANEL PN-11-A
230 VAC
POWER SUPPLY PANELS PN-12-A VT145 4(5Z3)
①
POWER SUPPLY CIRCUITS

TP9-124


CRYSTAL OSCILLATOR VT175 (1613) OR VT66 (6F6)
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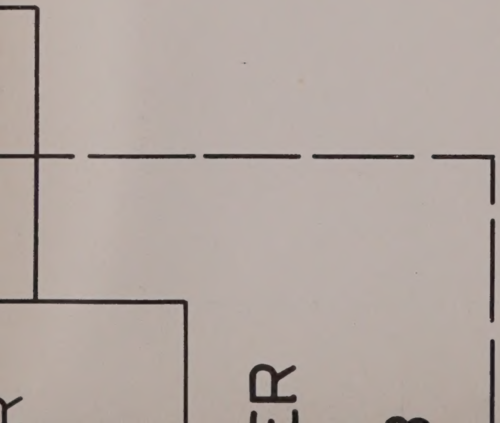
OSCILLATOR PANEL PN-9-B
RADIO FREQUENCY CIRCUITS
POWER AMPLIFIER VT204 2(HK24G) PUSH-PULL
②
MONITOR HEADSET
MONITOR RECTIFIER VT94 (6J5)
AMPLIFIER PANEL PN-8-B
LOCAL
REMOTE
③
SPEECH AMPLIFIER VT94 2(6J5) PUSH-PULL
DRIVER VT175 2(1613) OR VT66 2(6F6) PUSH-PULL
MODULATOR VT217 2(811) PUSH-PULL
KEYING RELAY
1000 CPS
AUDIO OSCILLATOR VT94 (6J5)
MODULATOR PANEL PN-10-B
AUDIO FREQUENCY CIRCUITS
TO R-F AND AUDIO CIRCUITS 230VAC 315 VDC 395 VDC 800 VDC
LINE INPUT 110-125V OR 220-250V AC
POWER CONTROL PANEL PN-13-B
230 VAC
CONTROL PANEL PN-11-A
230 VAC
POWER SUPPLY PANELS PN-12-A VT145 4(5Z3)
①
POWER SUPPLY CIRCUITS

WALL CHART
No. 1

Functional Block Diagram
of Radio Transmitters
BC-640-A and BC-640-B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WALL CHART No. 2

Sheet 2 of 2 Sheets

Schematic Diagram of Radio Transmitters BC-640-A and BC-640-B, Designating Interpanel Wiring.

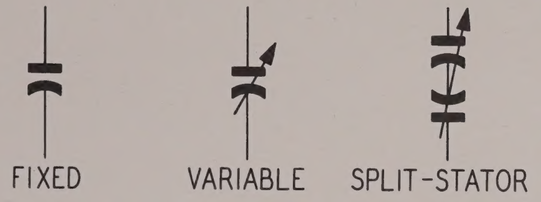
NOTES:

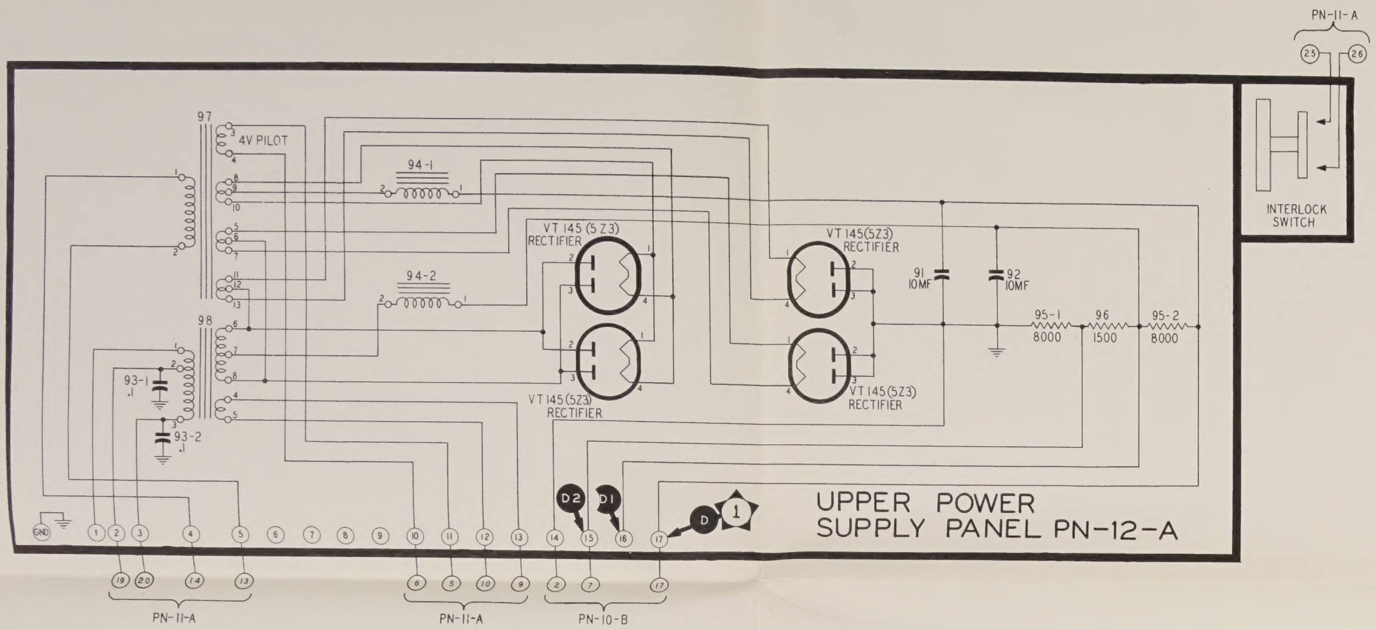
1-ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES IN MF UNLESS OTHERWISE MARKED.

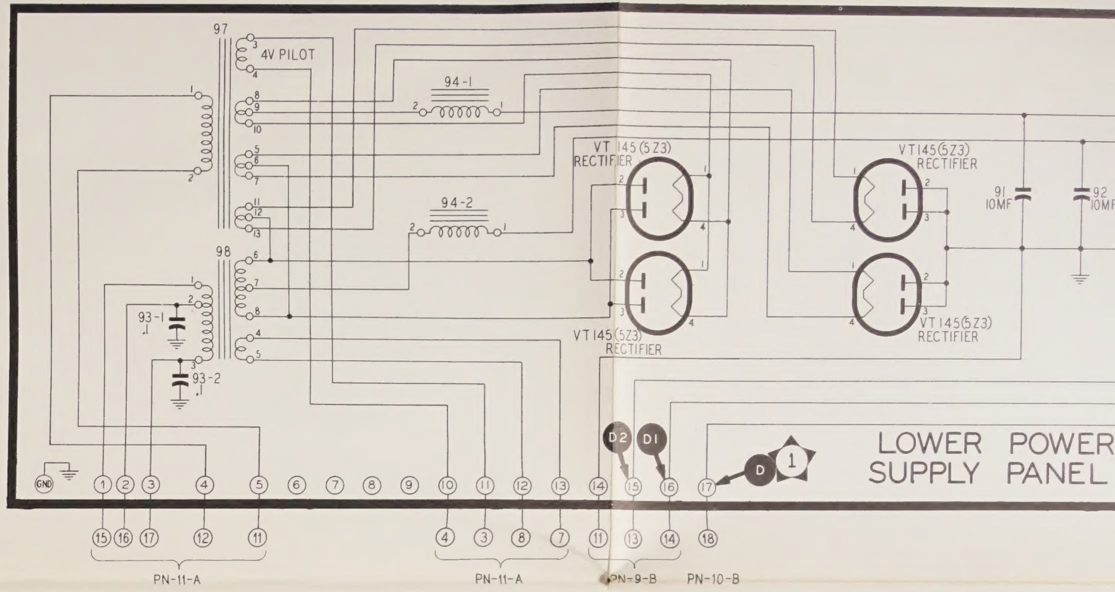
2-PHYSICALLY LOCATED ON RESPECTIVE CHASSIS SO THAT ELECTRICAL COUPLING EXISTS WHEN PANELS ARE ASSEMBLED.

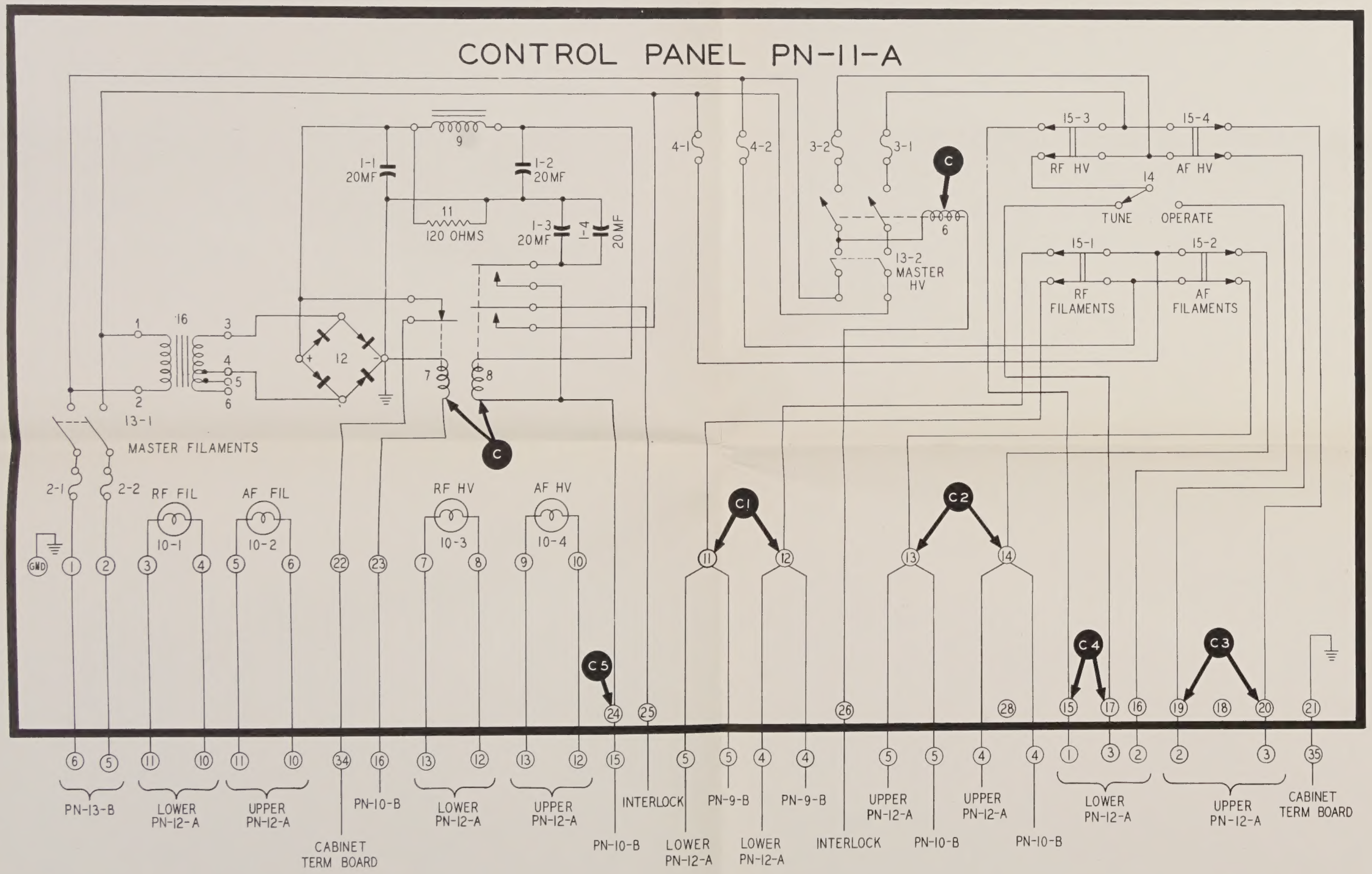
3-GROUND WIRES FROM EACH PANEL CABLED AND CONNECTED TO BINDING POST ON CABINET.

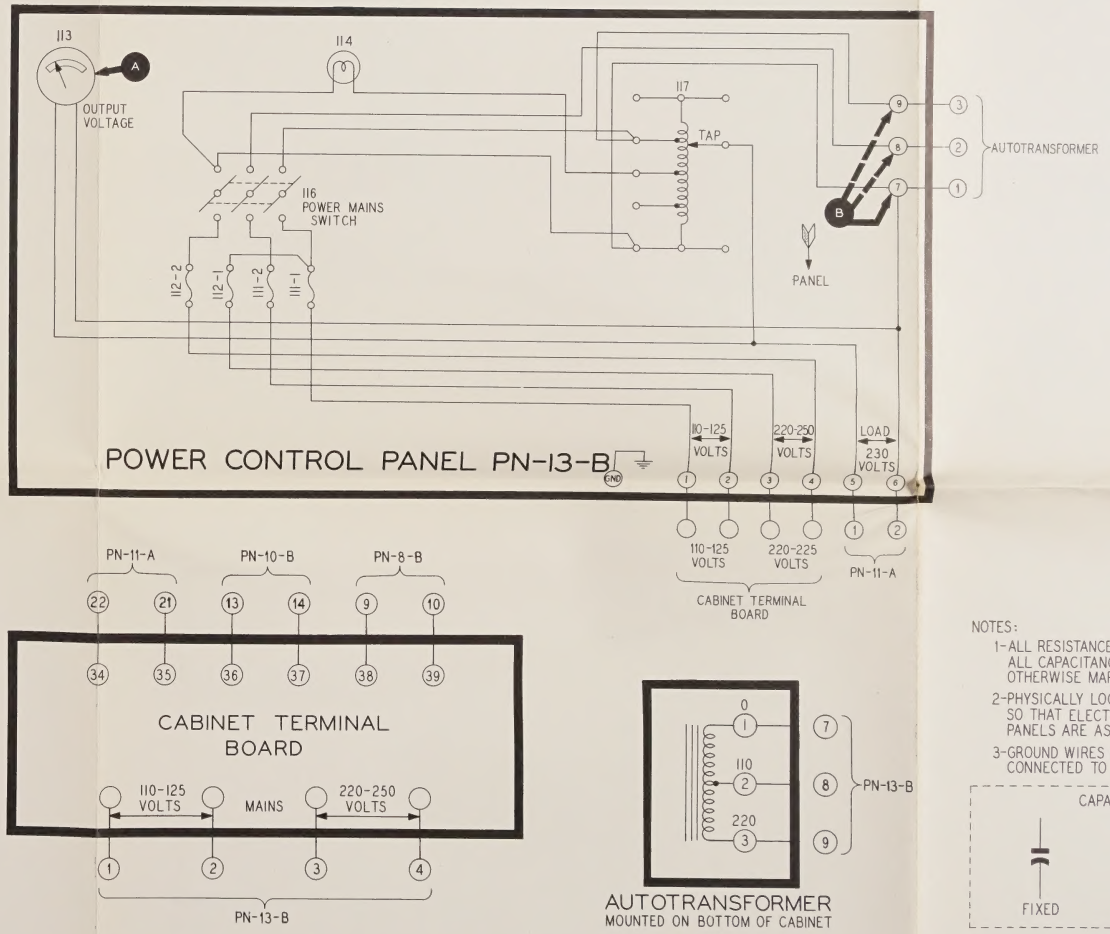
CAPACITOR SYMBOLS




PN-11-A
INTERLOCK SWITCH
97
4V PILOT
94-1
94-2
98
93-1 .1
93-2 .1
VT 145 (5Z3) RECTIFIER
91 10MF
92 10MF
95-1 8000
96 1500
95-2 8000
D2
D1
D
1
UPPER POWER SUPPLY PANEL PN-12-A
PN-11-A
PN-11-A
PN-10-B


97
4V PILOT
94-1
94-2
98
93-1 .1
93-2 .1
VT 145 (5Z3) RECTIFIER
91 10MF
92 10MF
D2
D1
D
1
LOWER POWER SUPPLY PANEL
PN-11-A
PN-11-A
PN-9-B
PN-10-B


CONTROL PANEL PN-11-A
1-1 20MF
9
1-2 20MF
11 120 OHMS
1-3 20MF
1-4 20MF
4-1
4-2
3-2
3-1
C
6
13-2 MASTER HV
15-3
15-4
RF HV
AF HV
14
TUNE
OPERATE
15-1
15-2
RF FILAMENTS
AF FILAMENTS
16
12
7
8
13-1
MASTER FILAMENTS
2-1
2-2
RF FIL
AF FIL
10-1
10-2
RF HV
AF HV
10-3
10-4
C1
C2
C5
C4
C3
GND
PN-13-B
LOWER PN-12-A
UPPER PN-12-A
CABINET TERM BOARD
PN-10-B
LOWER PN-12-A
UPPER PN-12-A
PN-10-B
INTERLOCK
PN-9-B
PN-9-B
LOWER PN-12-A
LOWER PN-12-A
INTERLOCK
UPPER PN-12-A
PN-10-B
UPPER PN-12-A
PN-10-B
LOWER PN-12-A
UPPER PN-12-A
CABINET TERM BOARD

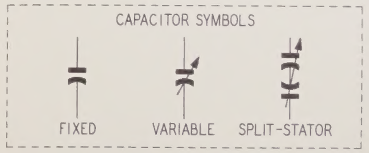

113
A
OUTPUT VOLTAGE
114
117
TAP
116 POWER MAINS SWITCH
12-2
12-1
11-2
11-1
AUTOTRANSFORMER
B
PANEL
POWER CONTROL PANEL PN-13-B
GND
110-125 VOLTS
220-250 VOLTS
LOAD 230 VOLTS
110-125 VOLTS
220-225 VOLTS
CABINET TERMINAL BOARD
PN-11-A
PN-11-A
PN-10-B
PN-8-B
CABINET TERMINAL BOARD
110-125 VOLTS
MAINS
220-250 VOLTS
PN-13-B
0
110
220
PN-13-B
AUTOTRANSFORMER
MOUNTED ON BOTTOM OF CABINET

NOTES:

1-ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES IN MF UNLESS OTHERWISE MARKED.

2-PHYSICALLY LOCATED ON RESPECTIVE CHASSIS SO THAT ELECTRICAL COUPLING EXISTS WHEN PANELS ARE ASSEMBLED.

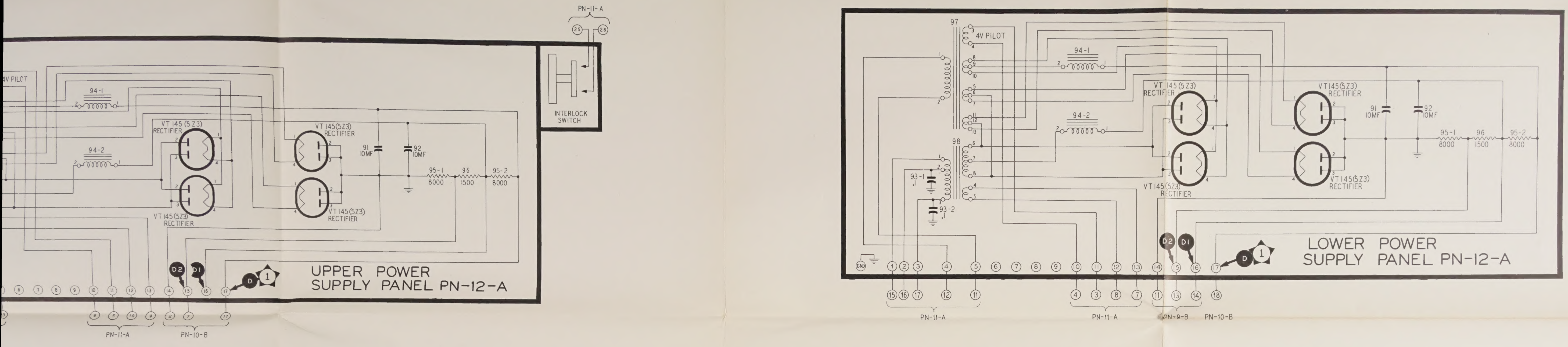
3-GROUND WIRES FROM EACH PANEL CABLED AND CONNECTED TO BINDING POST ON CABINET.

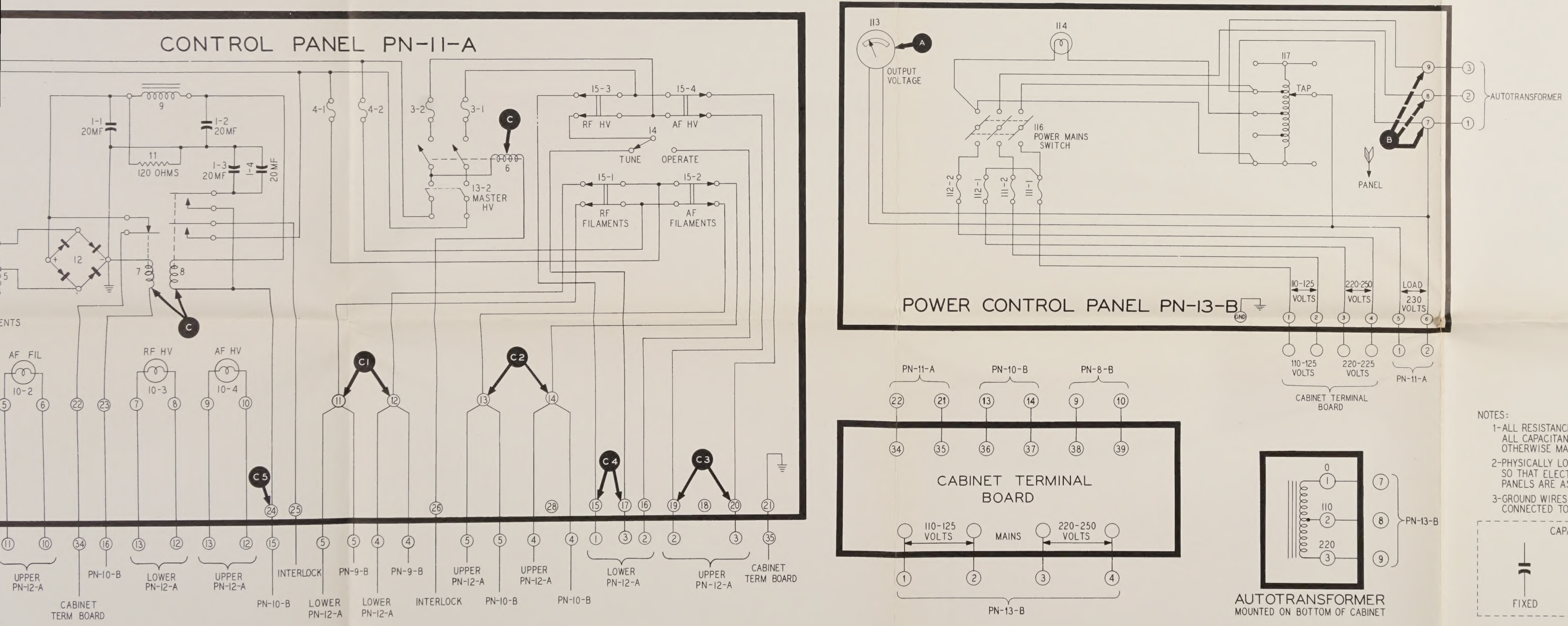

CAPACITOR SYMBOLS
FIXED
VARIABLE
SPLIT-STATOR

WA

Sch
mit
D

TP9-372


PN-11-A
INTERLOCK SWITCH
4V PILOT
94-1
94-2
VT 145 (5Z3) RECTIFIER
91 10MF
92 10MF
95-1 8000
96 1500
95-2 8000
D2
D1
D
1
UPPER POWER SUPPLY PANEL PN-12-A
PN-11-A
PN-10-B
97
98
93-1 .1
93-2 .1
GND
LOWER POWER SUPPLY PANEL PN-12-A
PN-11-A
PN-11-A
PN-9-B
PN-10-B

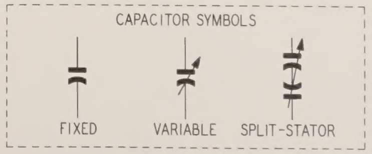

CONTROL PANEL PN-11-A
9
1-1 20MF
1-2 20MF
11 120 OHMS
1-3 20MF
1-4 20MF
12
7
8
4-1
4-2
3-2
3-1
6
13-2 MASTER HV
15-3
15-4
RF HV
AF HV
14
TUNE
OPERATE
15-1
15-2
RF FILAMENTS
AF FILAMENTS
C
C1
C2
C3
C4
C5
AF FIL
10-2
RF HV
10-3
AF HV
10-4
UPPER PN-12-A
CABINET TERM BOARD
PN-10-B
LOWER PN-12-A
UPPER PN-12-A
PN-10-B
INTERLOCK
LOWER PN-12-A
PN-9-B
LOWER PN-12-A
PN-9-B
INTERLOCK
UPPER PN-12-A
PN-10-B
UPPER PN-12-A
PN-10-B
LOWER PN-12-A
UPPER PN-12-A
CABINET TERM BOARD
113
OUTPUT VOLTAGE
A
114
117
TAP
116 POWER MAINS SWITCH
112-2
112-1
111-2
111-1
B
PANEL
AUTOTRANSFORMER
110-125 VOLTS
220-250 VOLTS
LOAD 230 VOLTS
POWER CONTROL PANEL PN-13-B
GND
110-125 VOLTS
220-225 VOLTS
CABINET TERMINAL BOARD
PN-11-A
PN-11-A
PN-10-B
PN-8-B
CABINET TERMINAL BOARD
110-125 VOLTS
MAINS
220-250 VOLTS
PN-13-B
0
110
220
PN-13-B
AUTOTRANSFORMER
MOUNTED ON BOTTOM OF CABINET

NOTES:

1-ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES IN MF UNLESS OTHERWISE MARKED.

2-PHYSICALLY LOCATED ON RESPECTIVE CHASSIS SO THAT ELECTRICAL COUPLING EXISTS WHEN PANELS ARE ASSEMBLED.

3-GROUND WIRES FROM EACH PANEL CABLED AND CONNECTED TO BINDING POST ON CABINET.

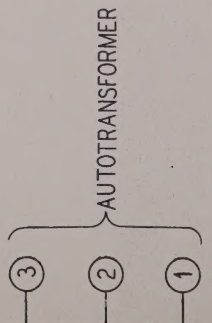

CAPACITOR SYMBOLS
FIXED
VARIABLE
SPLIT-STATOR

WORLD WIDE PHILCO SERVICE

WALL CHART No. 2

Sheet 2 of 2 Sheets

Schematic Diagram of Radio Transmitters BC-640-A and BC-640-B, Designating Interpanel Wiring.


③
②
①
AUTOTRANSFORMER

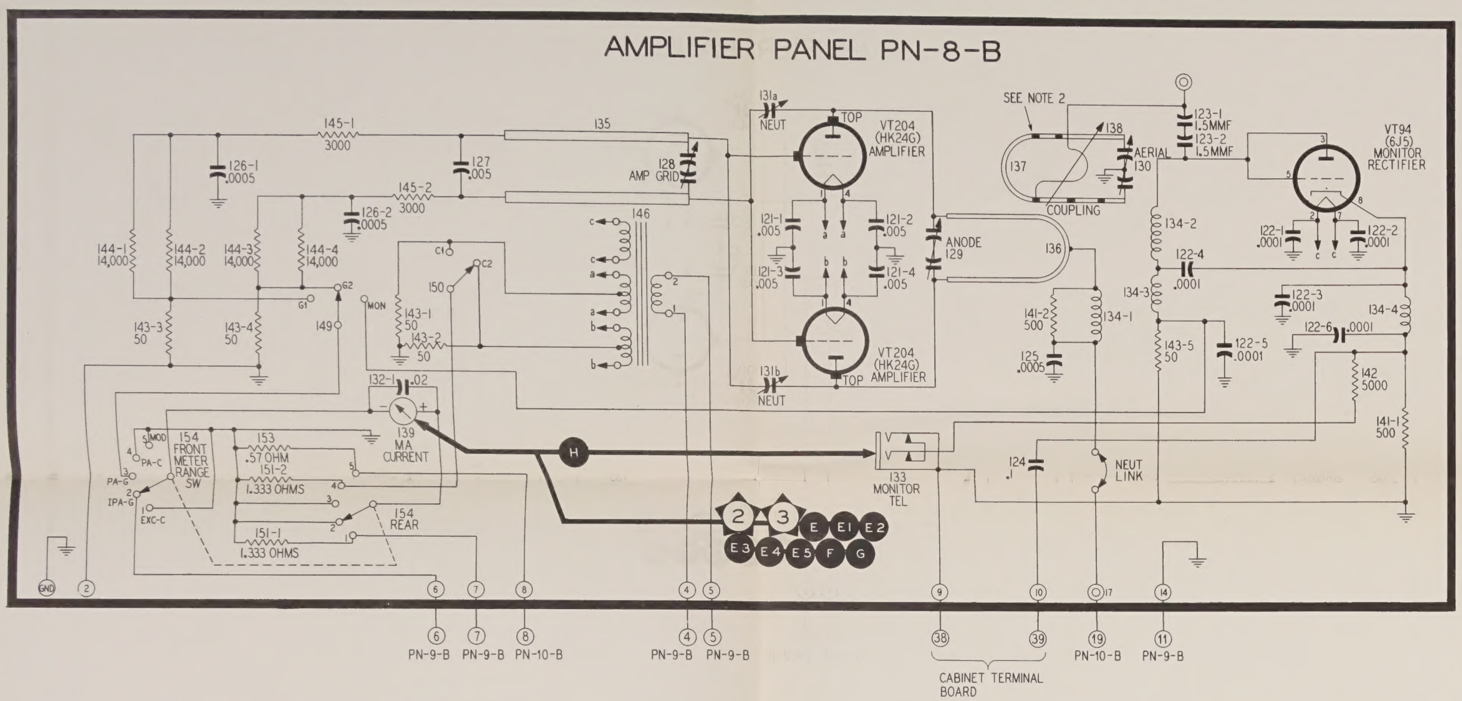
FIXED VARIABLE SPLIT-STATOR

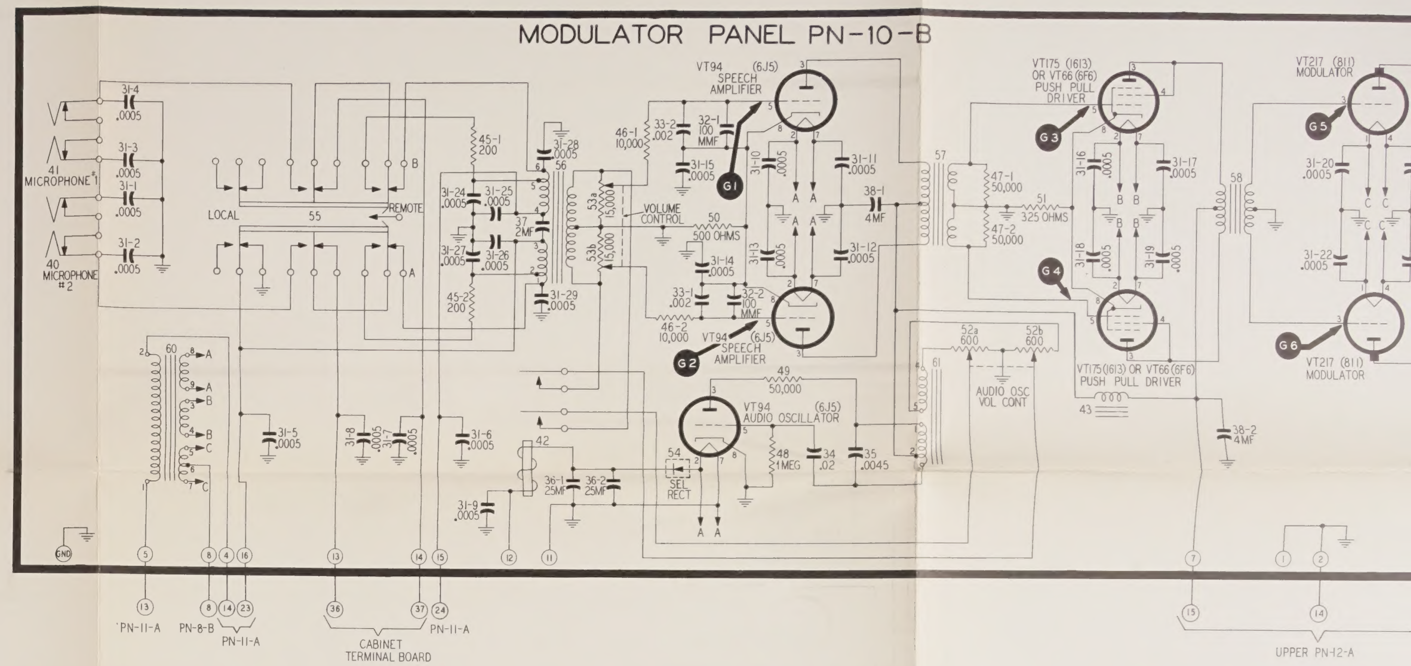
WORLD WIDE
PHILCO
SERVICE

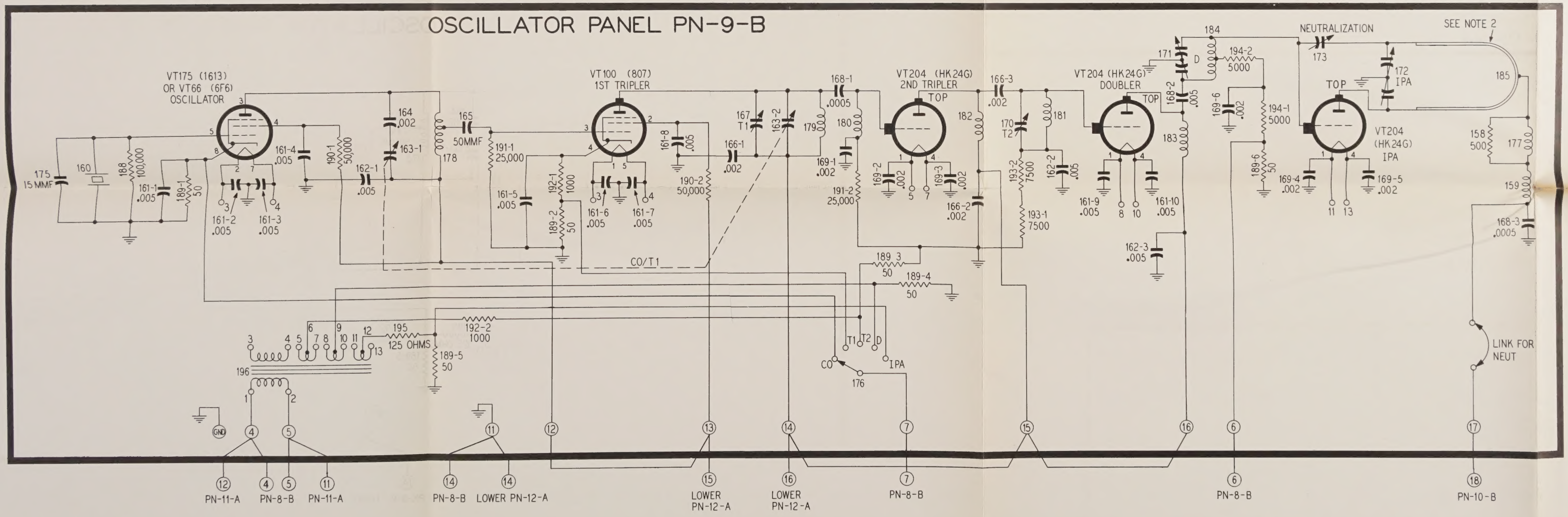
WALL CHART No. 2

Sheet 1 of 2 Sheets

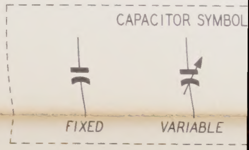
Schematic Diagram of Radio Transmitters BC-640-A and BC-640-B, Designating Interpanel Wiring.


AMPLIFIER PANEL PN-8-B
VT204 (HK24G) AMPLIFIER
VT204 (HK24G) AMPLIFIER
VT94 (6J5) MONITOR RECTIFIER
SEE NOTE 2
128 AMP GRID
129 ANODE
130 AERIAL
137
138
COUPLING
131a NEUT
131b NEUT
133 MONITOR TEL
139 MA CURRENT
154 FRONT METER RANGE SW
154 REAR
NEUT LINK
145-1 3000
145-2 3000
144-1 14,000
144-2 14,000
144-3 14,000
144-4 14,000
143-3 50
143-4 50
151-1 1,333 OHMS
151-2 1,333 OHMS
153 .57 OHM
142 5000
141-1 500
141-2 500
143-5 50
123-1 1.5MMF
123-2 1.5MMF
H
2 3 E E1 E2
E3 E4 E5 F G
PN-9-B
PN-9-B
PN-10-B
PN-9-B
PN-9-B
CABINET TERMINAL BOARD
PN-10-B
PN-9-B


MODULATOR PANEL PN-10-B
41 MICROPHONE #1
40 MICROPHONE #2
LOCAL
REMOTE
VT94 (6J5) SPEECH AMPLIFIER
VT94 (6J5) SPEECH AMPLIFIER
VT94 (6J5) AUDIO OSCILLATOR
VT175 (1613) OR VT66 (6F6) PUSH PULL DRIVER
VT175 (1613) OR VT66 (6F6) PUSH PULL DRIVER
VT217 (811) MODULATOR
VT217 (811) MODULATOR
VOLUME CONTROL
50 500 OHMS
AUDIO OSC VOL CONT
54 SEL RECT
51 325 OHMS
G1 G2 G3 G4 G5 G6
PN-11-A
PN-8-B
PN-11-A
CABINET TERMINAL BOARD
PN-11-A
UPPER PN-12-A


OSCILLATOR PANEL PN-9-B
VT175 (1613) OR VT66 (6F6) OSCILLATOR
VT100 (807) 1ST TRIPLER
VT204 (HK24G) 2ND TRIPLER
VT204 (HK24G) DOUBLER
VT204 (HK24G) IPA
TOP
NEUTRALIZATION
SEE NOTE 2
175 15 MMF
165 50MMF
CO/T1
176
CO T1 T2 D IPA
195 125 OHMS
196
LINK FOR NEUT
PN-11-A
PN-8-B
PN-11-A
PN-8-B
LOWER PN-12-A
LOWER PN-12-A
LOWER PN-12-A
PN-8-B
PN-8-B
PN-10-B

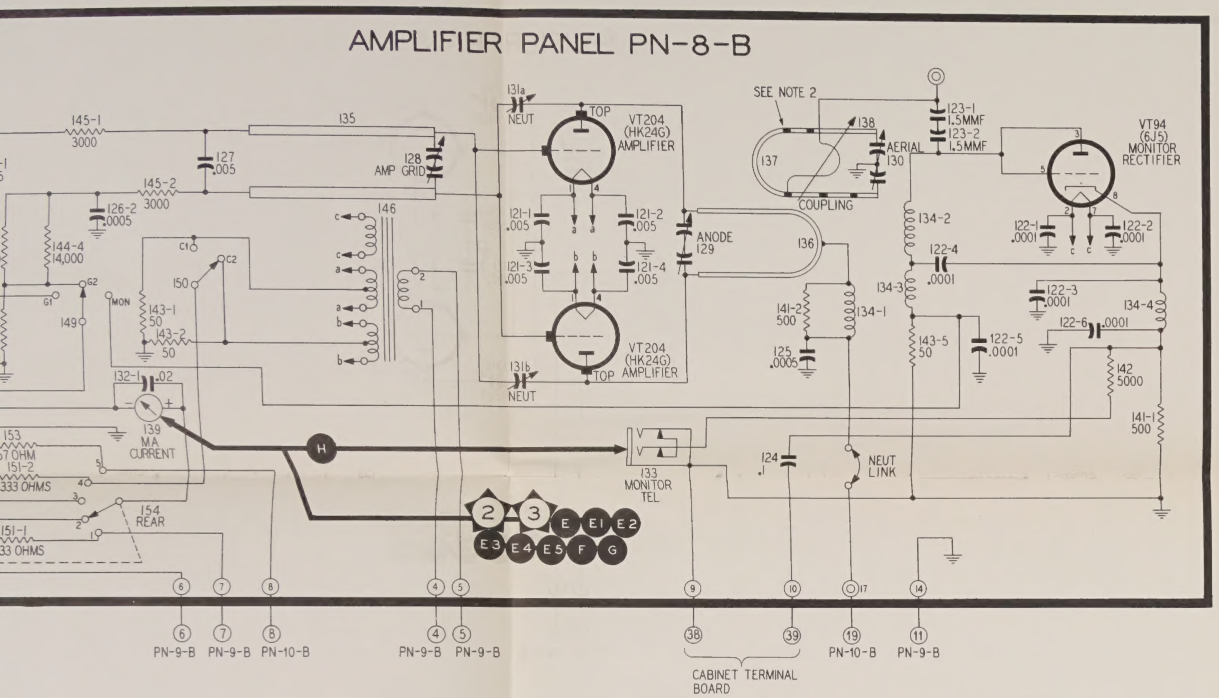
NOTES:
1-ALL RESISTANCE VALUES ARE IN
ALL CAPACITANCE VALUES IN M
OTHERWISE MARKED.
2-PHYSICALLY LOCATED ON RESP
SO THAT ELECTRICAL COUPLIN
PANELS ARE ASSEMBLED.
3-GROUND WIRES FROM EACH PA
CONNECTED TO BINDING POST

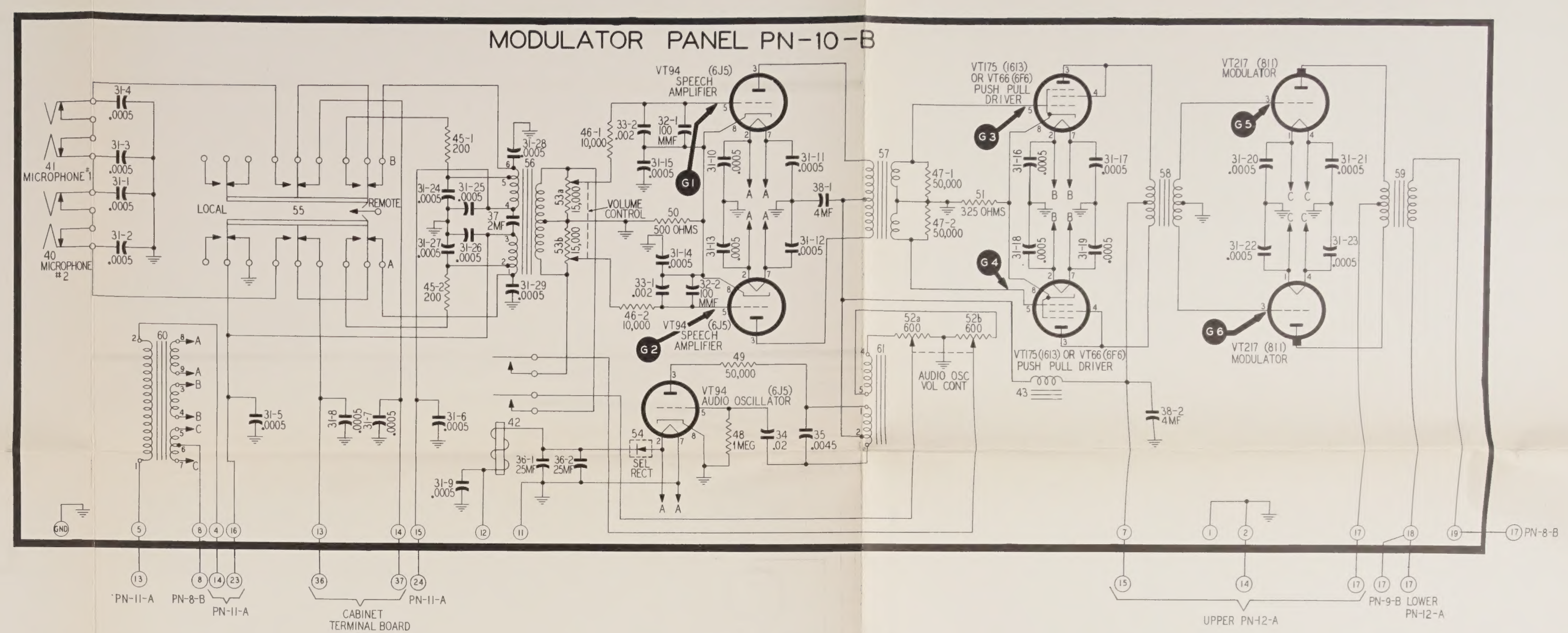

CAPACITOR SYMBOL
FIXED
VARIABLE

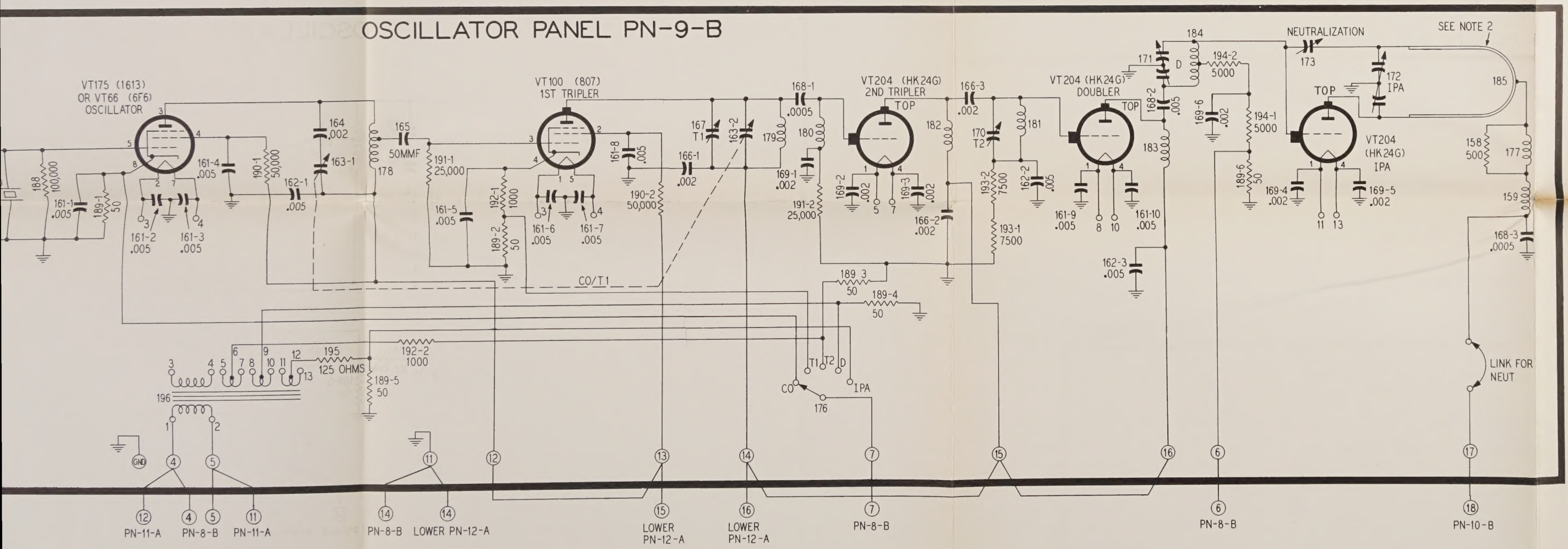
WALL CHA
Sheet 1 of 2

Schematic Diagram c
mitters BC-640-A a
Designating Interp

TP9-373


AMPLIFIER PANEL PN-8-B
VT204 (HK24G) AMPLIFIER
VT94 (6J5) MONITOR RECTIFIER
SEE NOTE 2
COUPLING
AERIAL
ANODE
AMP GRID
NEUT
NEUT LINK
139 MA CURRENT
133 MONITOR TEL
154 REAR
MON
PN-9-B
PN-10-B
CABINET TERMINAL BOARD


MODULATOR PANEL PN-10-B
VT94 (6J5) SPEECH AMPLIFIER
VT175 (1613) OR VT66 (6F6) PUSH PULL DRIVER
VT217 (811) MODULATOR
VT94 (6J5) AUDIO OSCILLATOR
41 MICROPHONE #1
40 MICROPHONE #2
LOCAL
REMOTE
VOLUME CONTROL
AUDIO OSC VOL CONT
SET RECT
GND
PN-11-A
PN-8-B
CABINET TERMINAL BOARD
UPPER PN-12-A
PN-9-B LOWER PN-12-A

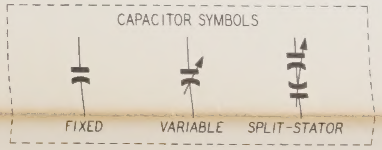

OSCILLATOR PANEL PN-9-B
VT175 (1613) OR VT66 (6F6) OSCILLATOR
VT100 (807) 1ST TRIPLER
VT204 (HK24G) 2ND TRIPLER
VT204 (HK24G) DOUBLER
VT204 (HK24G) IPA
NEUTRALIZATION
SEE NOTE 2
TOP
LINK FOR NEUT
CO/T1
195 125 OHMS
GND
PN-11-A
PN-8-B
LOWER PN-12-A
PN-10-B

NOTES:

1-ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES IN MF UNLESS OTHERWISE MARKED.

2-PHYSICALLY LOCATED ON RESPECTIVE CHASSIS SO THAT ELECTRICAL COUPLING EXISTS WHEN PANELS ARE ASSEMBLED.

3-GROUND WIRES FROM EACH PANEL CABLED AND CONNECTED TO BINDING POST ON CABINET.

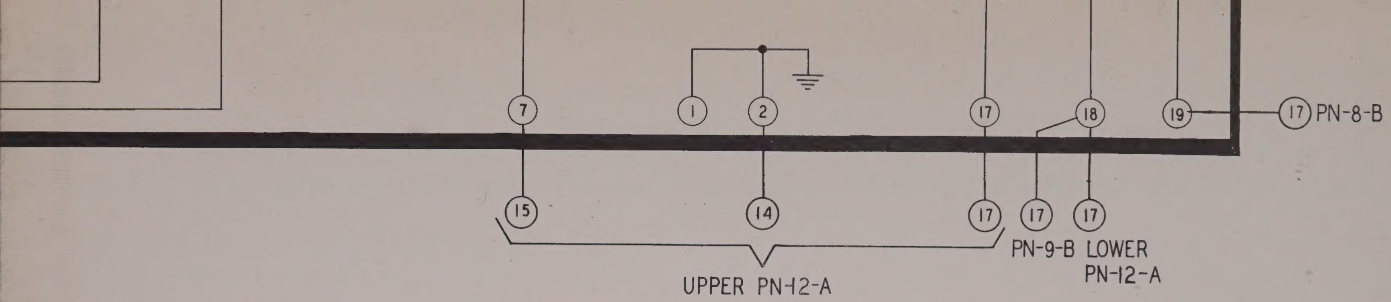

CAPACITOR SYMBOLS
FIXED
VARIABLE
SPLIT-STATOR

WORLD WIDE PHILCO SERVICE

WALL CHART No. 2

Sheet 1 of 2 Sheets

Schematic Diagram of Radio Transmitters BC-640-A and BC-640-B, Designating Interpanel Wiring.

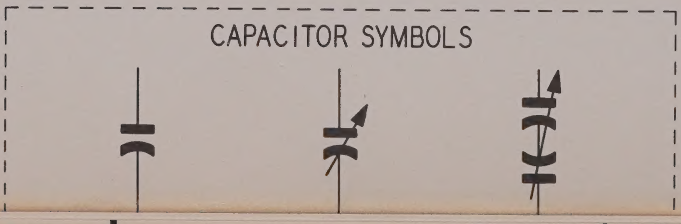

7
1
2
17
18
19
17 PN-8-B
15
14
17
17
17
UPPER PN-12-A
PN-9-B LOWER
PN-12-A

NOTES:

1-ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES IN MF UNLESS OTHERWISE MARKED.

2-PHYSICALLY LOCATED ON RESPECTIVE CHASSIS SO THAT ELECTRICAL COUPLING EXISTS WHEN PANELS ARE ASSEMBLED.

3-GROUND WIRES FROM EACH PANEL CABLED AND CONNECTED TO BINDING POST ON CABINET.


CAPACITOR SYMBOLS

COURSE OUTLINE

SUBJECT	TIME ALOTTED (HR.)	PAGE
Lecture No. 1, Introductory Information	¾	3
Lecture No. 2, General Description	1½	5
Experiment No. 1, Physical Identification	2	19
Lecture No. 3, Functional Block Analysis	1	20
Experiment No. 2, Major Test Points	2	24
Lecture No. 4, Analysis of Crystal-Oscillator Circuit	½	25
Experiment No. 3, Tuning and Trouble Shooting of the Crystal Oscillator	1½	27
Lecture No. 5, Analysis of Frequency-Multiplier Circuits	1¼	29
Experiment No. 4, Tuning and Trouble Shooting of the Frequency-Multiplier Circuits	2	31
Lecture No. 6, Analysis of Intermediate-Power-Amplifier Circuit	¾	33
Experiment No. 5, Tuning and Trouble Shooting of the Intermediate Power Amplifier	1½	34
Lecture No. 7, Analysis of Power-Amplifier and Output Circuits	1½	36
Experiment No. 6, Tuning, Adjustment, and Trouble-Shooting Procedures for the Power-Amplifier and Output Circuits	3	39
Review No. 1	3	41
Examination No. 1	2	41
Review of Examination No. 1	1	43
Lecture No. 8, Analysis of Audio-Amplifier and Modulator Circuits	1	43
Experiment No. 7, Trouble Shooting of the Audio-Amplifier and Modulator Circuits	2½	46
Lecture No. 9, Analysis of the Audio-Oscillator Circuit	¼	48
Experiment No. 8, Trouble Shooting of the Audio-Oscillator Circuit	1	50
Lecture No. 10, Analysis of Power-Supply Circuits	1	51
Experiment No. 9, Trouble Shooting of the Power-Supply Circuits	2	54
Lecture No. 11, Analysis of Power Control Circuits	½	55
Experiment No. 10, Trouble Shooting of the Power Control Circuits	1¾	57
Lecture No. 12, Analysis of D-C Meter Circuits	½	59
Lecture No. 13, Alignment and Adjustment	1½	63
Experiment No. 11, Alignment and Adjustment	2	63
Lecture No. 14, Trouble Shooting	4	63
Experiment No. 12, Trouble Shooting	4	77
Lecture No. 15, Preventive Maintenance	½	78
Experiment No. 13, Preventive Maintenance	3	79
Lecture No. 16, Special Information	¼	79
Review No. 2	3	81
Final Review	1½	81
Final Examination	5	81
Review of Final Examination	1	82
Total	61½	

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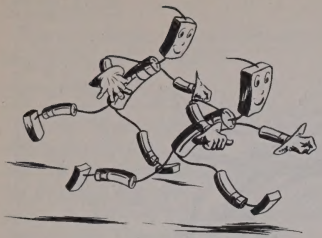
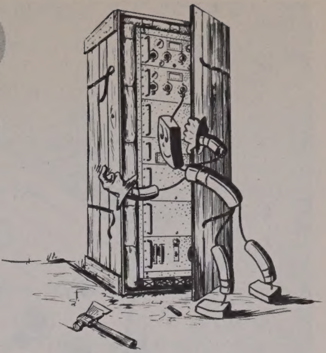
LECTURE No. 1

INTRODUCTORY INFORMATION





Radio Transmitters BC-640-A and BC-640-B are of the same general type. The circuit design of each transmitter is essentially the same; however, there are minor variations, such as the addition of some components and the omission of others. Since the basic operation is the same for both models, reference will be made only to Radio Transmitter BC-640-B, except when differences in the two equipments make it necessary to discuss Radio Transmitter BC-640-A.

Radio Transmitter BC-640-B provides single-channel radiophone operation in the very-high-frequency range, and is intended primarily for use with Radio Receiver BC-639-B, in ground installations, for point-to-point and aircraft-to-ground-station communication over a short range.

Before v-h-f equipment, such as the BC-640-B, BC-639-B, SCR-522, etc., was developed, other types of radio equipment were used almost exclusively for short-range communication. In certain instances, ordinary telephones were used for point-to-point communication.

The use of the earlier type of radio equipment, which operates at frequencies much lower than the BC-640-B, although excellent for communication purposes, does have a number of disadvantages, such as atmospheric static, which often makes it impossible to interpret received signals; conditions of the ionosphere, which causes fluctuating signals, and often makes reliable reception almost an impossibility; and finally, it is extremely difficult to direct, or beam, a low-frequency signal along a narrow path, and thereby limit the coverage, because of the great difficulties encountered in installing the necessary special types of antennas. In military use, beaming the signal along a narrow path is very desirable, since, by limiting the area of signal coverage, the interception of messages by an enemy will be more difficult and will depend not only upon their knowledge of the frequency being used, but also upon their position relative to the narrow signal path.

Telephones used for point-to-point communication purposes do not have the disadvantages mentioned above. However, other disadvantages, such as telephone-line installation problems, are present. Telephone-line installation problems, especially those due to rough terrain, have no simple solution and, therefore, are considered to be the major disadvantage of this type of communication system.

The basic problems just discussed contributed to the need for the development of v-h-f equipment, which operate at frequencies of 100 to 156 megacycles. It has been found that equipment designed to operate at these very high frequencies can be depended upon for effective communication virtually 24 hours a day, because varying conditions of the ionosphere and atmospheric static have very little effect upon these frequencies. The problems of antenna installation are relatively simple when compared to the problems of installing an antenna for communication at lower frequencies. V-H-F antennas are generally more efficient and much smaller physically. The small size facilitates the installation and use of special directive antenna arrays, which generally increase the effective range of v-h-f communication and concentrate the signal into a very narrow beam.

The use of v-h-f for reliable point-to-point communication purposes is limited to relatively short distances (approximately line of sight) by such factors as transmitter power, antenna height, and location. The actual distance of reliable communication may be regulated by controlling the antenna height and orientation. When both the receiving and transmitting antennas are located on very high hills, reliable communication over a distance of 100 miles or more is not uncommon, whereas antennas installed at normal heights above land will generally provide reliable communication over a distance of only about 30 miles. The presence of hills, large buildings, etc., which are located between the transmitting and receiving antennas and which are higher than both antennas, will interrupt the passage of the signal. Under such conditions, communication is made possible in some instances by utilizing the reflection properties of v-h-f signals. For instance, v-h-f communication from one side of a hill to the other side is normally impossible, but, by directing the signal at an object (hill, large building, etc.) which will reflect the signal to the desired point on the other side of the hill, communication is thereby made possible.

Hills, large buildings, etc., which prevent the passage of v-h-f signals, and proper antenna orientation may be utilized to good advantage for minimizing the signal strength in a particular direction. This makes it possible to minimize mutual interference between stations operating on the same frequency and which are located within communication distance of one another and, in military use, to minimize the chances

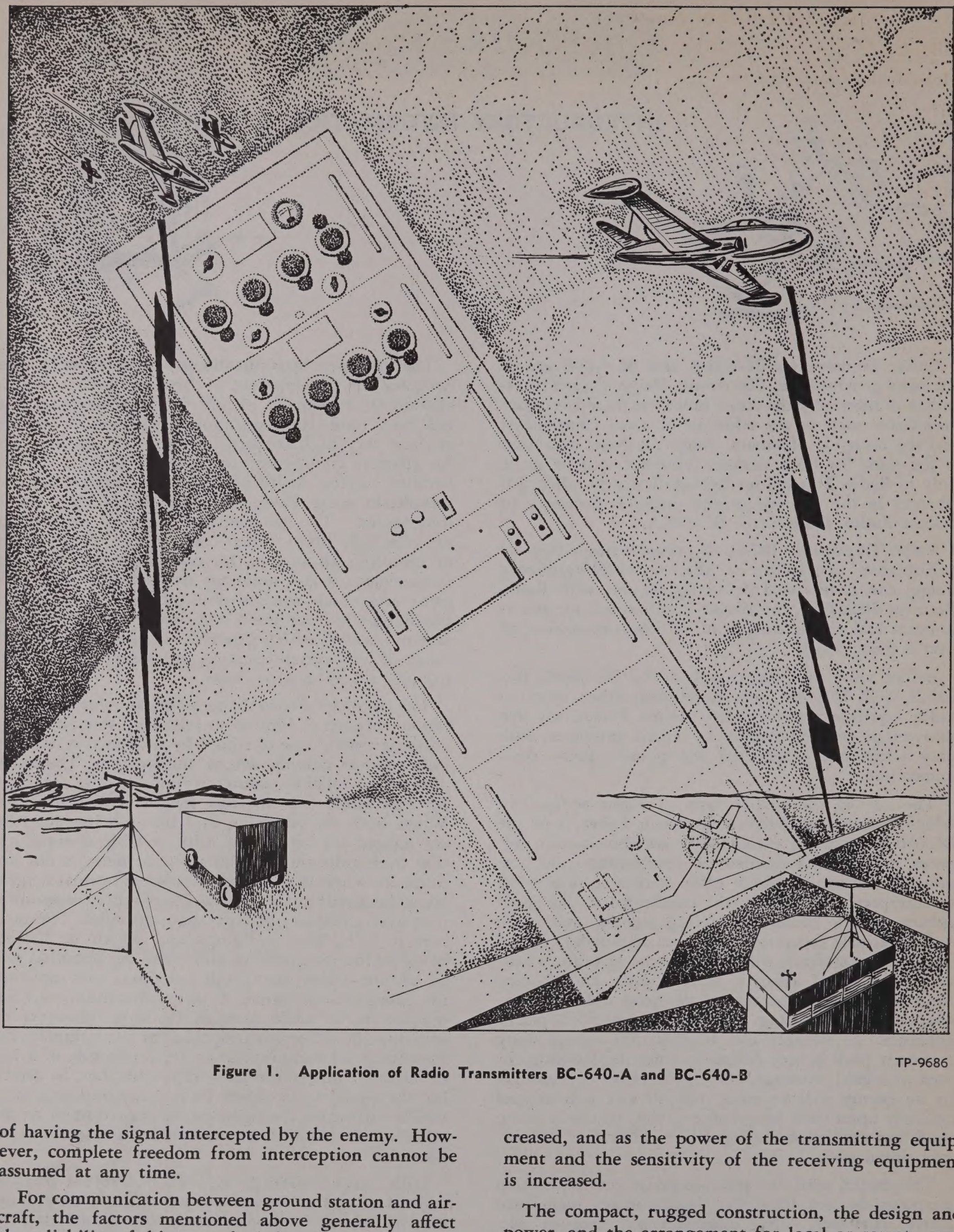


Figure 1. Application of Radio Transmitters BC-640-A and BC-640-B

TP-9686

of having the signal intercepted by the enemy. However, complete freedom from interception cannot be assumed at any time.

For communication between ground station and aircraft, the factors mentioned above generally affect the reliability of this type of v-h-f coverage. The actual effective range of such communication is 155 miles when the aircraft is at an altitude of 10,000 feet. This range is considered conservative for reasonably level country. It will generally increase as the height of the aircraft and that of the ground station antennas is increased, and as the power of the transmitting equipment and the sensitivity of the receiving equipment is increased.

The compact, rugged construction, the design and power, and the arrangement for local or remote control make Radio Transmitter BC-640-B adaptable for use as a ground installation in v-h-f radiophone communication systems for both point-to-point and aircraft communication. Figure 1 illustrates such a system.

LESSON PLAN No. 1

SUBJECT — TIME ALLOTTED: ¾ HR.

Introductory information.

OBJECTIVE

To provide an over-all picture of Radio Transmitters BC-640-A and BC-640-B.

INTRODUCTION

Radio Transmitters BC-640-A and BC-640-B are of the same general type. Since the basic operation is the same for both models, reference will be made only to Radio Transmitter BC-640-B, except when differences in the two equipments make it necessary to discuss Radio Transmitter BC-640-A.

SUBJECT MATERIAL

1. Primary purpose of Radio Transmitter BC-640-B.
   a. Type of operation.
   b. Equipment used with.
2. Need for v-h-f.
   a. Disadvantages of lower frequency operation.
   b. Disadvantages of telephone system for short-range point-to-point communication.
3. Advantages of v-h-f.
   a. Ionosphere, atmospheric static, etc.
   b. Antenna installations.
4. Limits of v-h-f.
   a. Factors of coverage.
   b. Reliable distance of point-to-point communication.
   c. Reflecting properties.
   d. Reliable distance of aircraft-to-ground communication.

CONCLUSIONS

The design, construction, and control arrangement provided in the transmitter make it easily adaptable for use in ground-station, v-h-f radiophone communication systems.

ORAL QUIZ

1. For what purpose was the BC-640-B primarily designed?

2. What is the effective v-h-f coverage between aircraft and ground over level country?

3. What general frequency range does the transmitter cover?

4. What are the advantages of v-h-f equipment as compared to radio equipment operating on a lower frequency, and as compared to telephone equipment for short-range communication?

5. What are the disadvantages of v-h-f?

6. What general factors limit the coverage of v-h-f?

7. How may the reflecting properties of v-h-f signals be utilized to advantage?

8. How may the coverage between aircraft and ground generally be increased?

9. In military use, why is beaming the signal along a narrow path desirable?

LECTURE No. 2

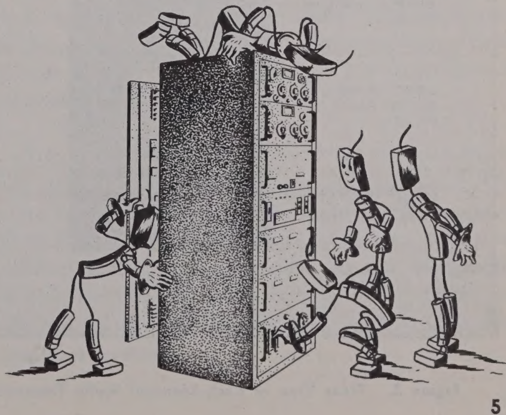
GENERAL DESCRIPTION

The BC-640-B equipment is capable of providing either amplitude-modulated voice transmission or modulated (1000-cycle) continuous-wave transmission (MCW), with a nominal output of approximately 50 watts. The frequency range of this transmitter is from 100 to 156 megacycles (3 to 1.92 meters wave length). The power output will vary from 51.5 watts at 100 mc. to 46 watts at 156 mc. Frequency changing is accomplished by substituting crystals and adjusting controls; no coils need be changed in spite of the wide frequency band covered.

This equipment may be used in either a mobile or fixed installation. It can be modulated locally by plugging a single-button carbon microphone into the front panel, or remotely by connecting wire lines from the remote operating position to the cabinet terminal board. Although voice modulation is normally used, the transmitter has a 1000-cycle audio oscillator for MCW transmission, if needed. The transmitter can be keyed satisfactorily at speeds up to 30 words per minute.

The primary power requirements are:

110-125 volts, 50/60 cycles, single phase, a.c., or
220-250 volts, 50/60 cycles, single phase, a.c.



The over-all size of the BC-640-B, including projections, is 72⅜ inches high, 21¼ inches long, and 20 inches deep; the total weight is 601½ pounds. Figure 2 shows a front view of Radio Transmitters BC-640-A and BC-640-B which are rack-mounted. Some of the major physical differences may be observed in the illustration.

Radio Transmitters BC-640-A and BC-640-B consist of the following major assemblies:

OFFICIAL NOMENCLATURE		FUNCTIONAL TITLE
BC-640-A	BC-640-B	
Amplifier panel PN-8-A	Amplifier panel PN-8-B	Final amplifier
Oscillator panel PN-9-A	Oscillator panel PN-9-B	R-F oscillator and driver
Modulator panel PN-10-A	Modulator panel PN-10-B	Audio input and modulator
Control panel PN-11-A	Control panel PN-11-A	Control panel
(2) Power supply panel PN-12-A	(2) Power supply panel PN-12-A	Power supply
Power control panel PN-13-A	Power control panel PN-13-B	Line-input control
Power-input transformer	Power-input transformer	Line-voltage step-up transformer
Cabinet CS-88-A	Cabinet CS-88-A	Transmitter housing

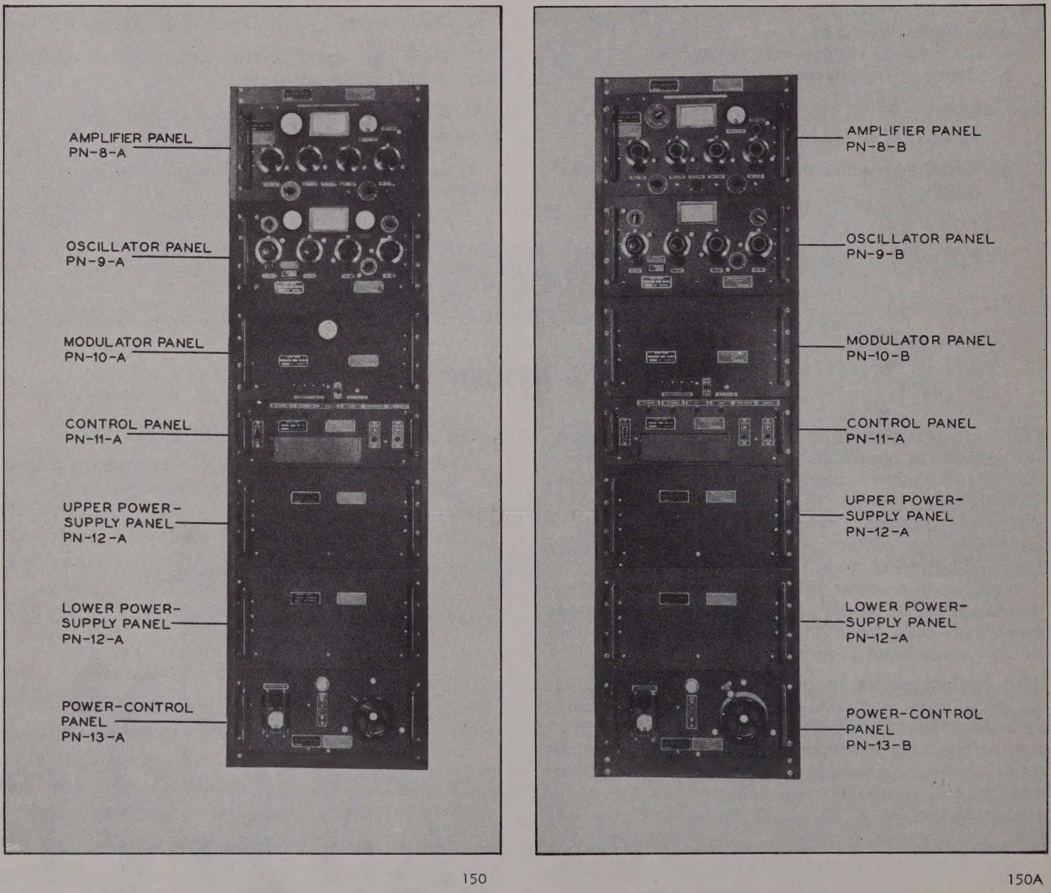

AMPLIFIER PANEL PN-8-A
OSCILLATOR PANEL PN-9-A
MODULATOR PANEL PN-10-A
CONTROL PANEL PN-11-A
UPPER POWER-SUPPLY PANEL PN-12-A
LOWER POWER-SUPPLY PANEL PN-12-A
POWER-CONTROL PANEL PN-13-A
AMPLIFIER PANEL PN-8-B
OSCILLATOR PANEL PN-9-B
MODULATOR PANEL PN-10-B
CONTROL PANEL PN-11-A
UPPER POWER-SUPPLY PANEL PN-12-A
LOWER POWER-SUPPLY PANEL PN-12-A
POWER-CONTROL PANEL PN-13-B
150
150A

Figure 2. Front View of Rack-Mounted Radio Transmitter BC-640-A (Left) and Radio Transmitter BC-640-B (Right)

CABINET CS-88-A

Cabinet CS-88-A provides mounting facilities for all the components of the transmitter, and also protects and shields the equipment. The over-all dimensions of the cabinet are 72⅜ inches high, 21¼ inches wide, and 18¼ inches deep; its total weight is 201½ pounds.

At the bottom of the cabinet there are four holes, for ⅜-inch bolts, in the gusset plates so that the cabinet may be bolted to the floor. In a fixed installation, the cabinet is usually mounted on wooden blocks, and the blocks in turn are securely fastened to the floor. In a mobile installation, the cabinet is mounted on rubber shockmounts and is secured at both the bottom and top, two additional holes being provided at the top of the cabinet for this purpose. When the cabinet is installed there should be 6 to 12 inches clearance at the sides for air circulation, and at least 17 inches at the rear of the cabinet for clearance of the door.

Openings, which are screened on the inside to prevent the entrance of insects and mice, are provided in the sides, top, and rear of the cabinet. A single door on three pin-hinges provides access to the rear of the rackmounted panels. This door is equipped with an interlock switch which disconnects the high-voltage supply when the door is open. This interlock is the *only* high-voltage safety device in the equipment. There are five compartments on the rear door; these compartments contain the following:

1. Master tuning charts forAmplifier Panel PN-8-B.

2. Master tuning charts for Oscillator Panel PN-9-B.

3. Blank front-panel tuning charts for Amplifier Panel PN-8-B.

4. Blank front-panel tuning charts for Oscillator Panel PN-9-B.

5. Over-all schematic diagram with parts list.

Below the door is a separate 7-inch panel, which is held in place with four screws. The removal of this panel provides ample clearance for access to the rear of the power-control panel, the power-input transformer, and the cabinet terminal board.

The cabinet terminal board has the necessary terminal connections for the external lines of the 110—125-volt or 220—250-volt power input, a remote-microphone line, a remote-monitor line, and a remote-signal-lamp line to indicate at the remote operating position whether the transmitter is available for remote speech input. These lines are normally connected from the remote operating position only when the transmitter is installed for remote operation.

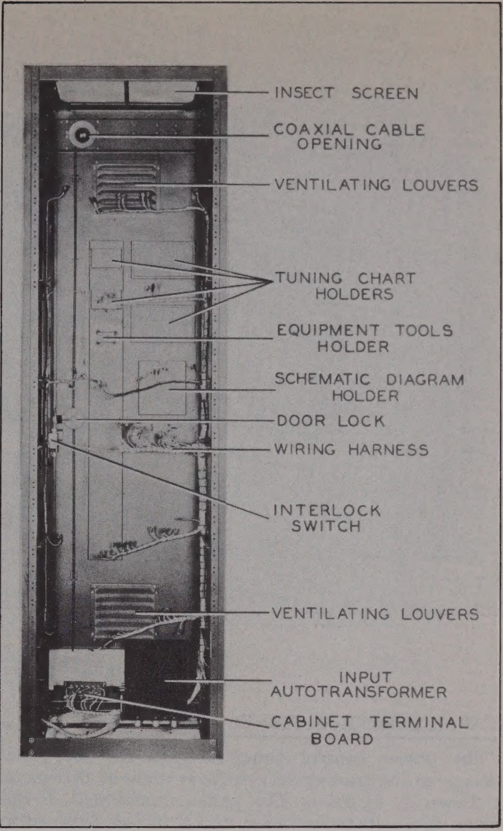


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Figure 3. Cabinet CS-88-A, Front View, Panels Removed

The autotransformer, which is located at the bottom of the cabinet, under the cabinet terminal board, is the power-input transformer. This transformer steps up the input voltage from 110 to 220 volts when a 110-volt input is used.

There is a hole at the bottom rear of each side of the cabinet, to provide an entrance for the input power lines and remote cables. Rubber grommets are placed in the holes for the protection of these cables. The coaxial transmission line enters the cabinet through a 2½-inch hole in the upper right-hand corner of the rear of the cabinet; this hole is faced with two pieces of bakelite.

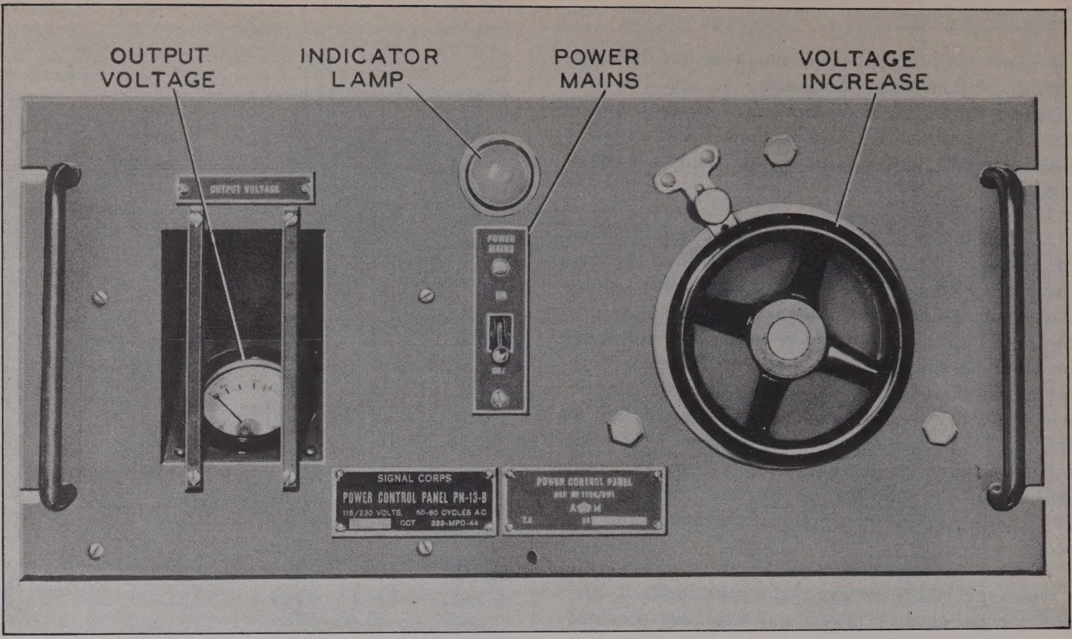


Figure 4. Power Control Panel PN-13-B, Front View

POWER CONTROL PANEL

The power control panel controls the line-input voltage to the transmitter. A front view of this panel is shown in figure 4. The panel, unmounted, is 8¾ inches high, 19 inches long, and 9 inches deep, overall, and it weighs 40 pounds.

The POWER MAINS switch (116), located at the center of the front panel, is a three-pole, single-throw switch. Regardless of which pair of line-input terminals are used, this switch controls the power supply to the entire transmitter. Mounted above the POWER MAINS switch is an indicator lamp, which is lighted when the POWER MAINS switch is in the closed position. This lamp, 114, is a clear pilot lamp with a candelabra base, and is mounted in a bull's-eye unit, 115, with a red insert. The pilot lamp may be removed, from the front of the panel, by first removing the glass jewel.

On the left-hand side of the front of the panel is an alternating-current voltmeter (113), which is permanently connected to the output load terminals. The scale on this meter is graduated from 0 to 300 volts, a.c., with a red line at 230 volts to indicate the correct load voltage. The meter is mounted on a $\frac{1}{32}$-inch steel cup-line panel that is recessed from the main panel, and is mounted at an angle of approximately 45 degrees with the front panel so that it may be easily read without stooping.

The large wheel at the right of the POWER MAINS switch is the VOLTAGE INCREASE wheel, which is provided with a dial lock; this wheel controls the position of the tap on the variable ratio transformer, 117, which compensates for various input voltages. The power control panels PN-13-A and PN-13-B are identical except that the dial-locking device on the VOLTAGE INCREASE wheel is omitted on the PN-13-A.

The power control panel, and all other panels of the transmitter, may be removed from the rack by disconnecting the leads from the terminal-strip assembly at the rear of the unit, and by removing the mounting screws on the front. See figures 4 and 5. The connections are made with standard closed-type solder lugs, mounted on machine-screw-type terminals and are mechanically secured with knurled nuts. On the PN-13-B, these leads include the primary power lines, which are terminated at terminals 1 and 2, if the line input voltage is 110 to 125 volts, a.c., or at terminals 3 and 4, if the line input voltage is 220 to 250 volts, a.c. In addition to the power leads, the three wires on terminals 7, 8, and 9, which connect the power-input transformer to the power control panel, and the leads at terminals 5 and 6, which carry the output load, must be removed. Each of the two pairs of input-power terminals is fused. These fuses are mounted on a natural-bakelite terminal board at the rear of the panel; the fuse ratings are plainly marked.

POWER SUPPLY PANELS

The radio transmitter is supplied with two power supply panels, the upper Power Supply Panel PN-12-A and the lower Power Supply Panel PN-12-A, which are rack-mounted one above the other in the cabinet. The front of each panel is blank, containing no controls or meters. The procedure for removal of the panel is identical to that for Power Control Panel PN-13-B. There are eighteen leads connected to a terminal-strip assembly at the rear of each panel. The

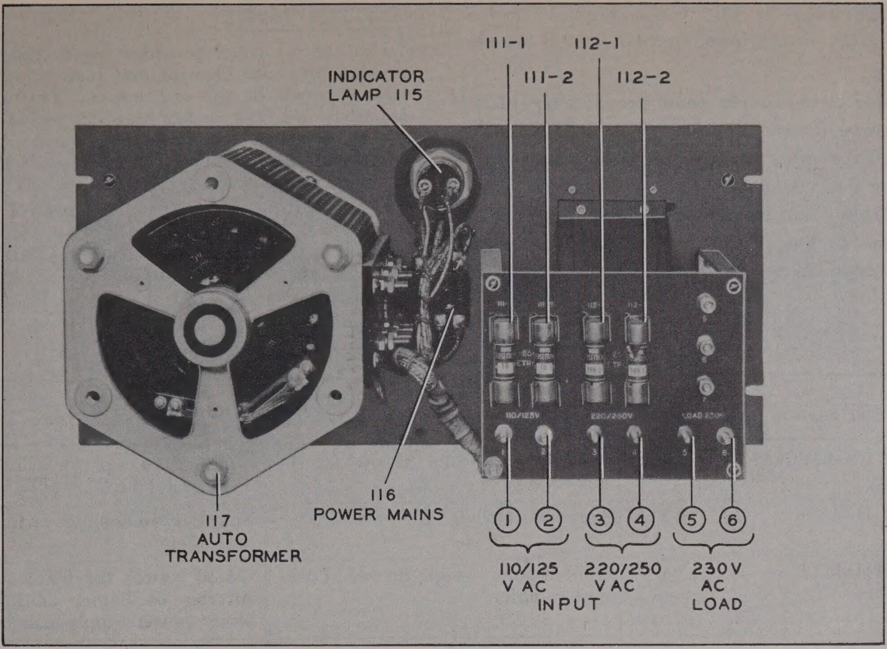

111-1
112-1
INDICATOR LAMP 115
111-2
112-2
117 AUTO TRANSFORMER
116 POWER MAINS
① ② ③ ④ ⑤ ⑥
110/125 V AC
220/250 V AC
INPUT
230V AC LOAD
154

Figure 5. Power Control Panel PN-13-B, Rear View

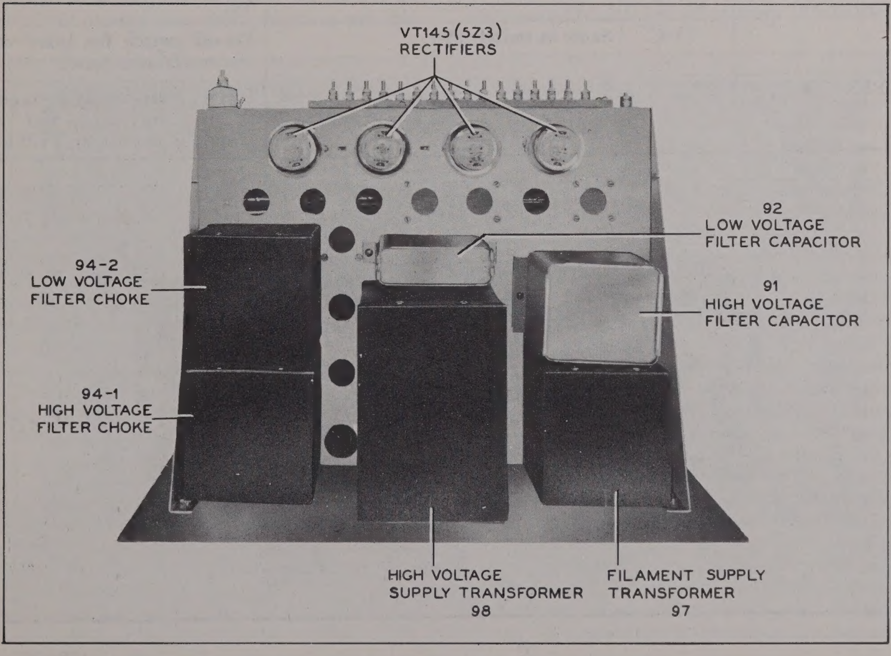

VT145 (5Z3) RECTIFIERS
92 LOW VOLTAGE FILTER CAPACITOR
94-2 LOW VOLTAGE FILTER CHOKE
91 HIGH VOLTAGE FILTER CAPACITOR
94-1 HIGH VOLTAGE FILTER CHOKE
HIGH VOLTAGE SUPPLY TRANSFORMER 98
FILAMENT SUPPLY TRANSFORMER 97
TP-9680

Figure 6. Power-Supply Panel PN-12-A, Top View

panel (unmounted) is 10½ inches high, 19 inches long, and 14½ inches deep, over-all, and it weighs 84 pounds.

The lower power-supply panel provides the plate-supply voltage for the amplifier panel and the oscillator panel; the upper panel provides the plate supply voltage for the modulator panel. Filament power is obtained from filament transformers mounted on the various panels. The primary power for these transformers is supplied by the control panel.

CONTROL PANEL

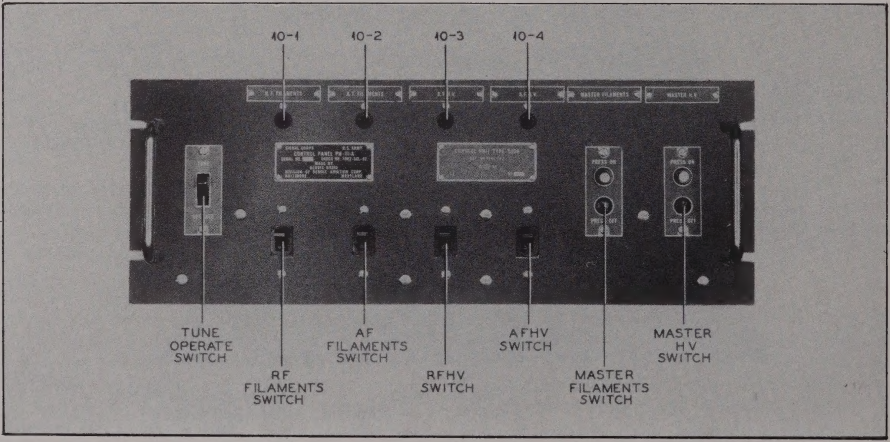
The control panel provides the necessary controls for switching the filament and plate supplies to the various panels of the transmitter. This panel (unmounted) is 6³¹⁄₃₂ inches high, 19 inches long, and 8⅝ inches deep, over-all and it weighs 27 pounds. The control panel may be removed from the cabinet in the same manner as the other panels.

The operating controls for the control panel are located on the front of the panel. The description and function of these controls are given in Chart 1, and the locations are shown in figure 7.

CHART 1

OPERATING CONTROLS OF CONTROL PANEL PN-11-A

Panel Designation	*Reference Symbol*	*Description*	*Function*
MASTER FILAMENTS	13-1	Double-pole, single-throw, push-button type.	Supplies voltage to switches 15-1, 15-2, and 13-2.
MASTER H.V.	13-2	Same as switch 13-1.	Supplies voltage to switches 15-3 and 15-4.
R.F. FILAMENTS	15-1	Double-pole, single-throw, flush-type tumbler.	On-off switch for filament voltage to the oscillator, amplifier and lower power-supply panels.
A.F. FILAMENTS	15-2	Same as switch 15-1.	On-off switch for filament voltage to the modulator and upper power-supply panels.
R.F.H.V.	15-3	Same as switch 15-1.	On-off switch for plate voltage to the oscillator and amplifier panels through TUNE-OPERATE switch 14.
A.F.H.V.	15-4	Same as switch 15-1.	On-off switch for plate voltage to the modulator panel.
TUNE-OPERATE	14	Single-pole, double-throw, tumbler switch.	Halves plate-supply voltage to tubes in the oscillator and amplifier panels when set at TUNE.



TP-9672

Figure 7. Control Panel PN-11-A, Front View

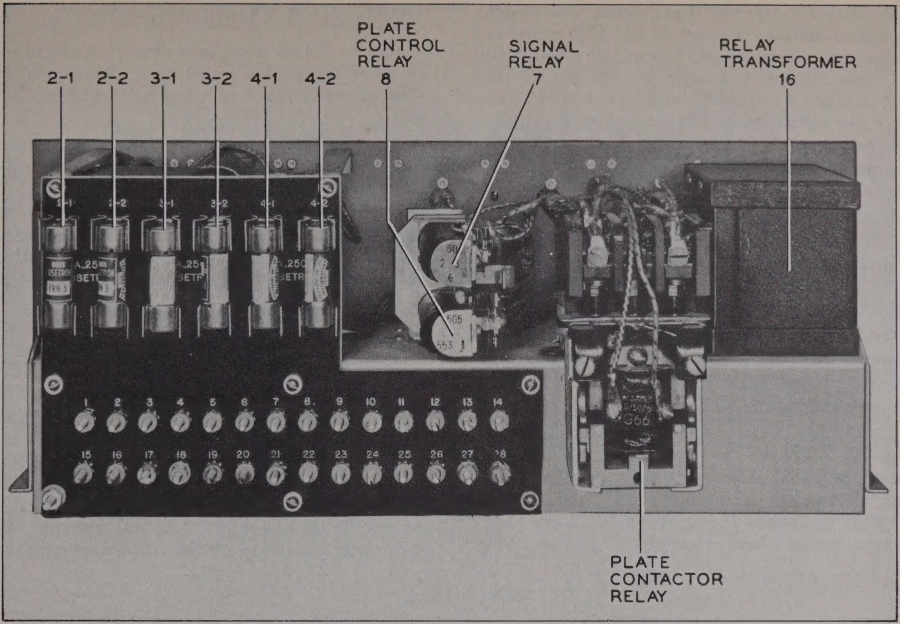


PLATE CONTROL RELAY 8
SIGNAL RELAY 7
RELAY TRANSFORMER 16
2-1
2-2
3-1
3-2
4-1
4-2
PLATE CONTACTOR RELAY
153

Figure 8. Control Panel PN-11-A, Rear View

The four switches 15-1, 15-2, 15-3, and 15-4 are normally kept in the ON position. These controls are used mainly for service work on the transmitter so that individual units may be switched on. When the transmitter is in normal use, these switches are concealed by a cover plate, which is held in position by four screws.

Above each of the four covered tumbler switches is a switchboard-type pilot lamp (10-1, 10-2, 10-3, and

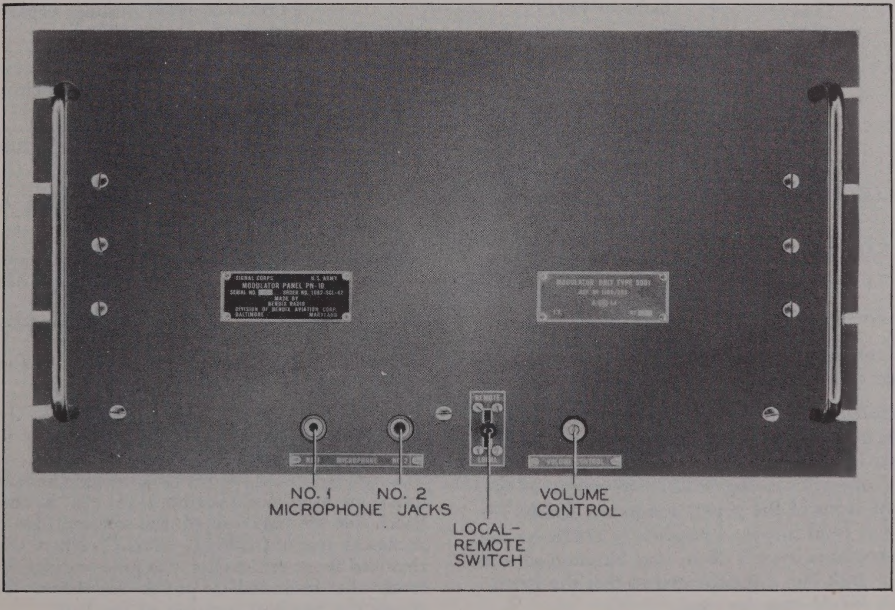

SIGNAL CORPS U.S. ARMY
MODULATOR PANEL PN-10
SERIAL NO. ORDER NO. 1087-SCL-42
MADE BY
BENDIX RADIO
DIVISION OF BENDIX AVIATION CORP.
BALTIMORE MARYLAND
NO. 1
NO. 2
MICROPHONE JACKS
LOCAL-REMOTE SWITCH
VOLUME CONTROL
TP-9670

Figure 9. Modulator Panel PN-10-B, Front View

10-4). The proper lamp will light when the switch with which it is associated is set at the ON position. To remove any of these lamps, first remove the glass jewel, and then remove the lamp by the use of the special tool which is supplied with the tool kit accompanying the transmitter. All fuses for the equipment, with the exception of the power-line fuses at the rear of the power control panel, are mounted on the rear of the control panel. Fuses 2-1 and 2-2 are in series with the supply terminals of the MASTER FILAMENTS switch. Fuses 3-1 and 3-2 are in series with the lines between the output terminals of the MASTER H.V. switch, and the input terminals of the R.F.H.V. switch. Fuses 4-1 and 4-2 are in series with the output terminals of the MASTER FILAMENTS switch and the input terminals of the R.F. FILAMENTS and A.F. FILAMENTS switches. All of these fuses are cartridge-type fuses.

MODULATOR PANEL

The modulator panel provides high-level plate modulation for the power amplifier. This panel (unmounted) is 10½ inches high, 19 inches long, and 15 inches deep, over-all, and it weighs 48 pounds. The procedure for removing it from the cabinet is the same as that of the other panels.

The modulator-panel operating controls are located at the front of the panel, as shown in figure 9. Speech input is provided for either local or remote operation, the type of operation being selected by the lever key (55), on the front of the panel, designated REMOTE-LOCAL. For local speech operation a single-button carbon microphone, type T-48-A, may be plugged into Jack No. 1. Jack No. 2 is provided so that the British microphone BT-23 may be used.

OSCILLATOR PANEL

The oscillator panel provides the necessary r-f energy to drive the power amplifier at the output frequency. The power output to the final amplifier is about 15 watts.

The over-all dimensions of the panel (unmounted) are 10½ inches high, 19 inches long, and 16¼ inches deep, and it weighs 39 pounds.

The operating controls and meters are located on the front of the panel. The description and function of these controls is given in CHART 2, and the physical locations are shown in figure 11.

The dial locking devices provided on oscillator panel PN-9-B are omitted on oscillator panel PN-9-A. The function of the CO-T1-T2-D-IPA switch on the PN-9-A is to place the CATHODE CURRENT meter in the proper cathode circuit.

Two meters, the IPA GRID CURRENT meter (186), which measures the current in the intermediate-power-amplifier grid circuit, and the CATHODE CURRENT meter (187), which measures the cathode current of each tube on the oscillator panel, are used on oscillator panel PN-9-A, but are omitted on PN-9-B. The functions of the meters omitted on PN-9-B are accomplished by the M.A. CURRENT meter on amplifier panel PN-8-B.

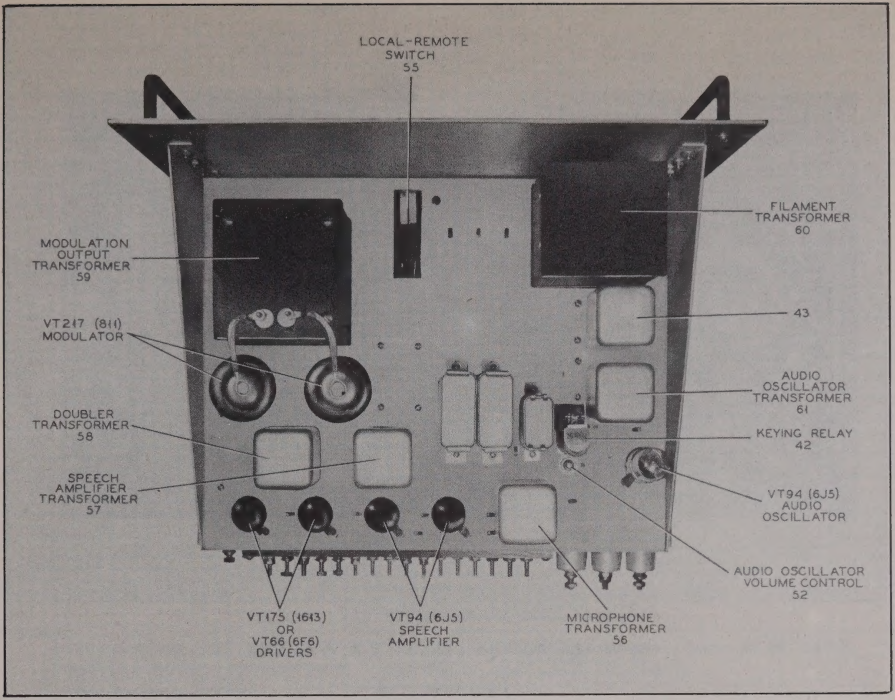
The rectangular opening between the CO/T1 and T2 dials provides facilities for plugging in the crystal from the front of the transmitter.

A double plug, with its terminals short-circuited, functions as a neutralizing link. It is on the left-hand side of the rear of the chassis; the associated socket is marked NEUT. LINK. When the plug is removed from this socket, the plate voltage is removed from the intermediate-power amplifier. Figure 13 shows the physical location of the link.

CHART 2

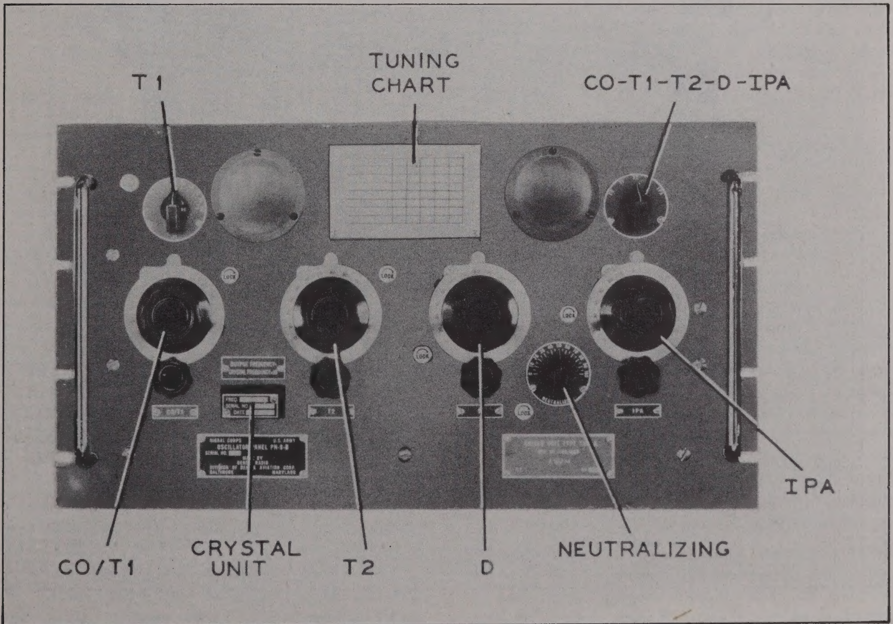
OPERATING CONTROLS OF OSCILLATOR PANEL PN-9-B

Panel Designation	*Description*	*Function*
CO/T1	Dial tuning assembly, dual, vernier-scale type.	Controls two ganged capacitors, 163-1 and 163-2, which tunes the plate circuits of the oscillator and 1st tripler.
T1	Knob pointer with indicator line.	Controls plate-tank-circuit trimmer capacitor 167 of the 1st-tripler stage.
T2	Same as CO/T1.	Controls plate tuning capacitor 170 of the 2nd-tripler stage.
D	Same as CO/T1.	Controls plate tuning capacitor 171 of doubler, and grid capacitor 171 of i-p-a stage.
IPA	Same as CO/T1.	Controls plate tuning capacitor 172 of i-p-a stage.
NEUTRALIZATION	Same as T1.	Controls i-p-a neutralizing capacitor 173.
CO-T1-T2-D-IPA	Five-position wafer switch, with knob as on T1.	Connects cathode circuit selected to METER RANGE MILLIAMPERES switch on PN-8-B.


LOCAL-REMOTE SWITCH 55
FILAMENT TRANSFORMER 60
MODULATION OUTPUT TRANSFORMER 59
43
VT217 (811) MODULATOR
AUDIO OSCILLATOR TRANSFORMER 61
DOUBLER TRANSFORMER 58
KEYING RELAY 42
SPEECH AMPLIFIER TRANSFORMER 57
VT94 (6J5) AUDIO OSCILLATOR
AUDIO OSCILLATOR VOLUME CONTROL 52
VT175 (1613) OR VT66 (6F6) DRIVERS
VT94 (6J5) SPEECH AMPLIFIER
MICROPHONE TRANSFORMER 56

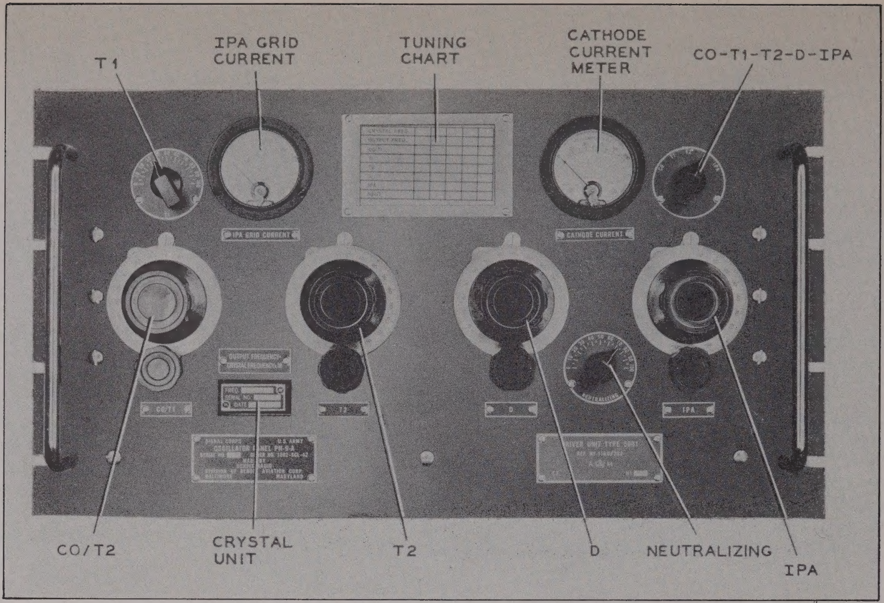
166

Figure 10. Modulator Panel PN-10-B, Top View


T1
TUNING CHART
CO-T1-T2-D-IPA
IPA
CO/T1
CRYSTAL UNIT
T2
D
NEUTRALIZING

TP-9674

Figure 11. Oscillator Panel PN-9-B, Front View


T1
IPA GRID CURRENT
TUNING CHART
CATHODE CURRENT METER
CO-T1-T2-D-IPA
CO/T2
CRYSTAL UNIT
T2
D
NEUTRALIZING
IPA

TP-9675

Figure 12. Oscillator Panel PN-9-A, Front View

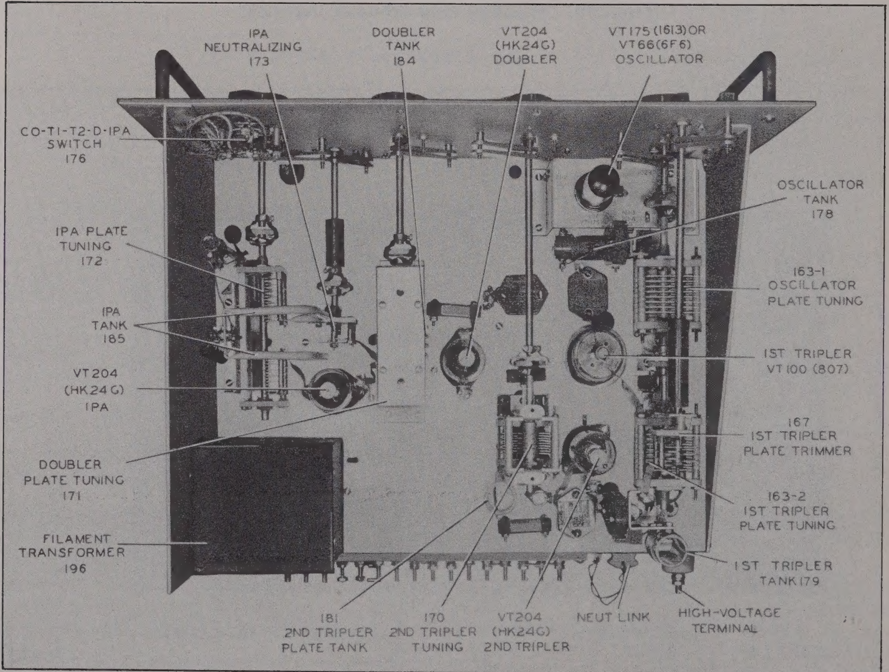

IPA NEUTRALIZING 173
DOUBLER TANK 184
VT204 (HK24G) DOUBLER
VT175 (1613) OR VT66 (6F6) OSCILLATOR
CO-T1-T2-D-IPA SWITCH 176
OSCILLATOR TANK 178
IPA PLATE TUNING 172
163-1 OSCILLATOR PLATE TUNING
IPA TANK 185
1ST TRIPLER VT100 (807)
VT204 (HK24G) IPA
167 1ST TRIPLER PLATE TRIMMER
DOUBLER PLATE TUNING 171
163-2 1ST TRIPLER PLATE TUNING
FILAMENT TRANSFORMER 196
1ST TRIPLER TANK 179
181 2ND TRIPLER PLATE TANK
170 2ND TRIPLER TUNING
VT204 (HK24G) 2ND TRIPLER
NEUT LINK
HIGH-VOLTAGE TERMINAL

Figure 13. Oscillator Panel PN-9-B, Top View

AMPLIFIER PANEL

The amplifier panel contains the final-amplifier stage of the transmitter. It supplies about 50 watts of power to the coaxial transmission line. This panel is 10½ inches high, 19 inches long, and 16¼ inches deep, over-all, and it weighs 41½ pounds.

The description and function of the operating controls on the amplifier panel are given in CHART 3, and the locations are shown in figure 14.

The plate-line shorting bar is located on the plate-line-inductor tubing, 136. The grid-line shorting bar is mounted on the grid-line-inductor tubing, 135, which is located under the chassis.

The flexible antenna coupling strip is mounted on the inductor tubing of the antenna tuning circuit, 138. The PN-8-A features an adjustable tap to perform the function of the flexible strip on the PN-8-B.

The output terminal, at the rear of the amplifier panel, provides a plug-in connection for the antenna cable. This plug is held in place by four screws on the protective plate. A balanced, untuned coaxial transmission line, with a characteristic impedance of 72 ohms, current-feeds a half-wave vertical antenna. This antenna is the Signal Corps type RC-81, which is normally used when the transmitter is to be employed for general communication purposes where directivity is not desired. Antenna Mast AN-56-A, which is a 50-foot tower, is generally used to support the antenna. Such an installation is shown in figure 1.

CHART 3

OPERATING CONTROLS ON AMPLIFIER PANEL PN-8-B

Panel Designation	*Description*	*Function*	
		BC-640-B	BC-640A
AERIAL*	Dial tuning assembly, vernier, provided with dial locking device.	Controls antenna coupling capacitor 130.	Same as BC-640-B.
COUPLING*	Same as AERIAL.	Controls coupling between the final-amplifier-plate inductance and the antenna inductance.	Same as BC-640-B.
ANODE*	Same as AERIAL.	Controls plate tuning capacitor 129 of the final amplifier.	Same as BC-640-B.
NEUT.*	Nickel-silver dial with black bakelite knob; provided with dial locking device.	Controls neutralizing capacitors 131A and 131B of the final amplifier.	Same as BC-640-B.
C1/C2	Two-position wafer switch and knob pointer with indicator line.	Selects the cathode circuit to be connected to the METER RANGE MILLIAMPERES switch.	Selects the tube whose cathode current is to be measured by the CATHODE CURRENT meter.
G1-G2-MON	Three-position wafer switch and knob pointer with indicator line.	Selects the grid circuit of either tube in the final amplifier, or the diode circuit of the monitor rectifier and connects it to the METER RANGE MILLIAMPERES switch.	Selects the grid circuit of either tube in the final amplifier, or the diode circuit of the monitor rectifier and connects it to the GRID CURRENT meter.
METER RANGE MILLIAMPERES	Five-position, two-bank wafer switch with knob pointer and indicator line.	Selects range of M.A. CURRENT METER.	Omitted.

*Dial locking devices omitted on PN-8-A.

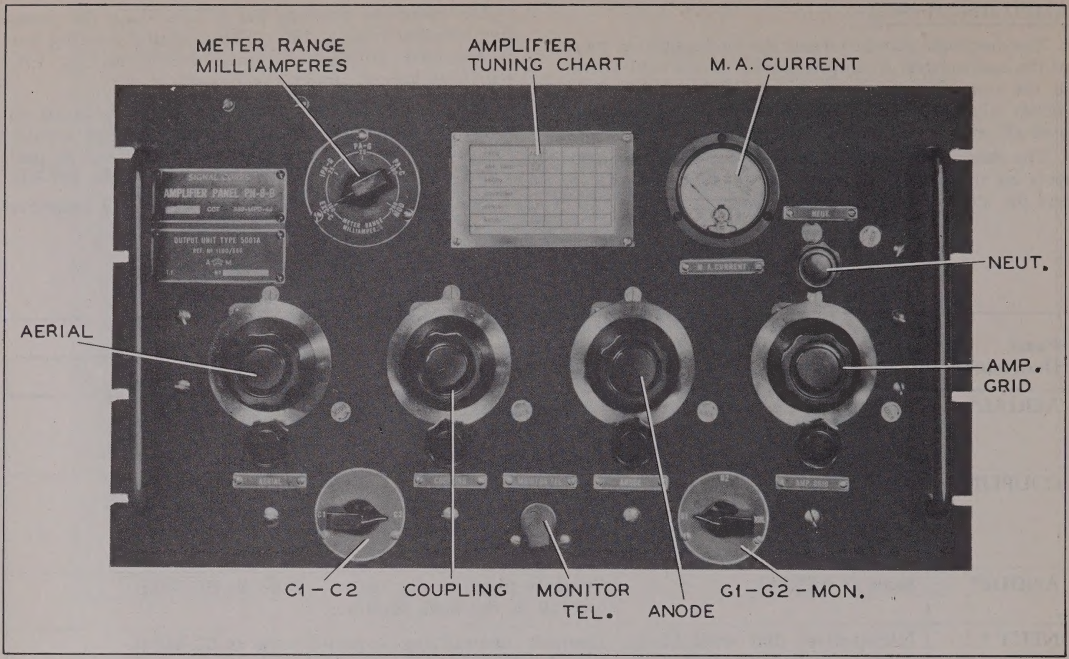
At the bottom center of Amplifier Panel PN-8-B is the MONITOR TEL jack, 133, as shown in figure 14. By plugging a headset into this jack, the modulated output of the transmitter may be monitored. The spring-mounted dust cover shown in the figure is omitted on Amplifier Panel PN-8-A.

On Amplifier Panel PN-8-A there are two meters which are eliminated on the PN-8-B. These meters are the CATHODE CURRENT meter, 140, and the GRID CURRENT meter, 139. On the PN-8-B the function of these meters is accomplished by the M.A. MILLIAMMETER.

A top view of the PN-8-B is shown in figure 16. The NEUT. LINK plug, on the rear of the chassis, removes the high voltage from the final-amplifier plates, when it is disconnected.

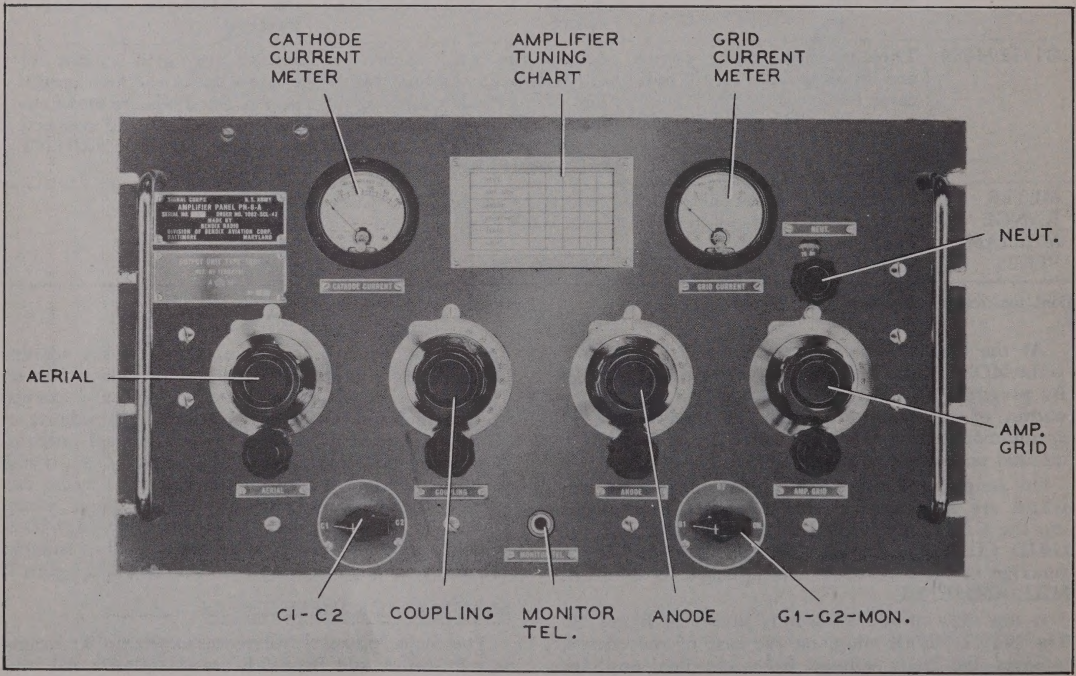
SUMMARY OF DIFFERENCES

The major physical differences of Radio Transmitters BC-640-A and BC-640-B are as follows: All tuning controls and other variable controls on the BC-


METER RANGE MILLIAMPERES
AMPLIFIER TUNING CHART
M. A. CURRENT
NEUT.
AERIAL
AMP. GRID
C1 – C2
COUPLING
MONITOR TEL.
ANODE
G1 – G2 – MON.

TP-9676

Figure 14. Amplifier Panel PN-8-B, Front View


CATHODE CURRENT METER
AMPLIFIER TUNING CHART
GRID CURRENT METER
NEUT.
AERIAL
AMP. GRID
C1 - C2
COUPLING
MONITOR TEL.
ANODE
G1-G2-MON.

TP-9677

Figure 15. Amplifier Panel PN-8-A, Front View

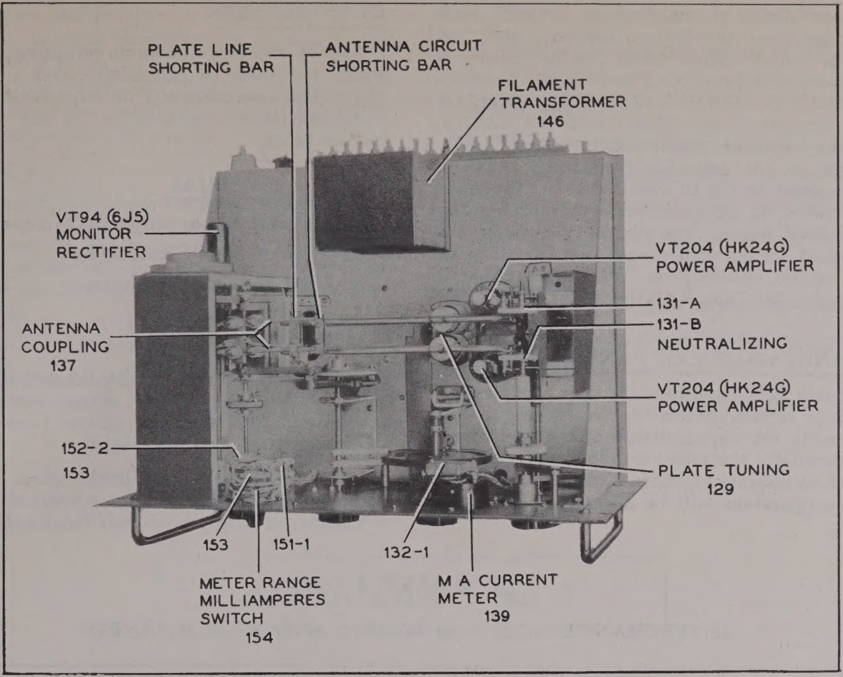
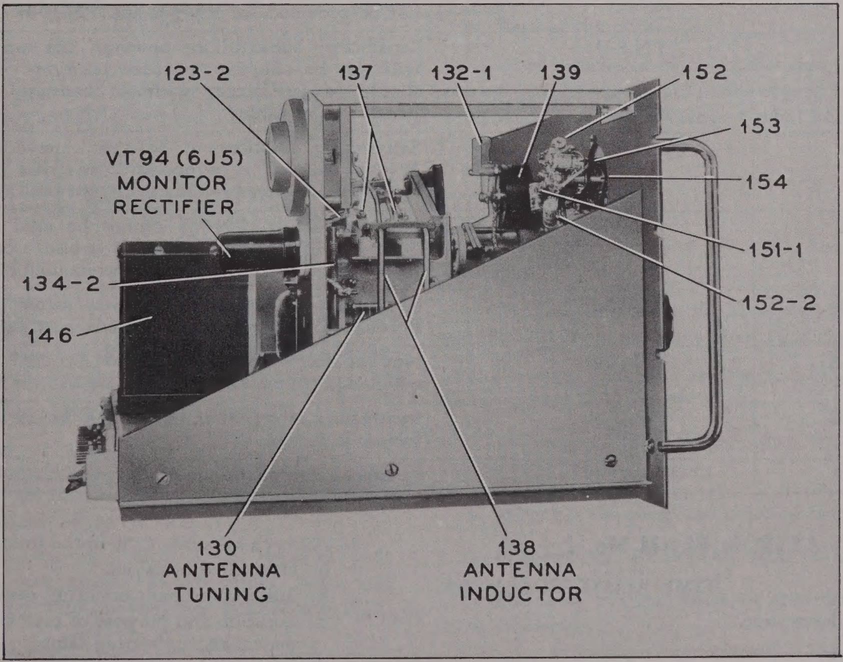


PLATE LINE SHORTING BAR
ANTENNA CIRCUIT SHORTING BAR
FILAMENT TRANSFORMER 146
VT94 (6J5) MONITOR RECTIFIER
VT204 (HK24G) POWER AMPLIFIER
131-A
131-B NEUTRALIZING
ANTENNA COUPLING 137
VT204 (HK24G) POWER AMPLIFIER
152-2
153
PLATE TUNING 129
153
151-1
132-1
METER RANGE MILLIAMPERES SWITCH 154
M A CURRENT METER 139

TP-9679

Figure 16. Amplifier Panel PN-8-B, Top View


123-2
137
132-1
139
152
153
154
VT94 (6J5) MONITOR RECTIFIER
151-1
134-2
152-2
146
130 ANTENNA TUNING
138 ANTENNA INDUCTOR

TP-9678

Figure 17. Amplifier Panel PN-8-B, Left Side View

640-B are provided with dial locking devices. Such devices prevent the controls from creeping, and thus changing the circuit values when the equipment is subjected to severe vibration. The BC-640-A features the MODULATOR ANODE CURRENT meter, on the modulator panel; the IPA GRID CURRENT meter, on the oscillator panel; and the GRID CURRENT meter on the amplifier panel. All of these meters are omitted on the BC-640-B, and the functions are accomplished on amplifier panel PN-8-B by the M.A. CURRENT meter. The dial of this meter has three calibrated scales, with ranges of 0 to 30, 0 to 100, and 0 to 200 milliamperes; the proper range is selected by the METER RANGE MILLIAMPERES switch.

INTERCHANGEABILITY OF PANELS

Under certain field conditions, it may be necessary to interchange certain panels of the BC-640-A and BC-640-B. Since the circuit design of the two transmitters is essentially the same, certain panels may be interchanged, as indicated in CHART 4. In most cases however, the operation will be affected in some respects.

INTRODUCTION

The BC-640-B is a medium-power radio transmitter which is capable of providing either amplitude-modulated voice transmission or modulated (1000-cycle) continuous-wave transmission in the very-high-frequency range.

SUBJECT MATERIAL

1. Nominal carrier output and frequency range.
2. Fixed or mobile installation.
3. Local or remote operation.
4. MCW transmission.
5. Power-supply requirements.

6. Draw a chart on the blackboard to indicate the physical positions of the major assemblies of the transmitter, and give the official nomenclature and functional title of each assembly.

7. If equipment is available, place the assembly to be studied in view of the students; otherwise, draw a blackboard diagram of each front panel.

CHART 4

INTERCHANGEABILITY OF BC-640-A AND BC-640-B PANELS

Original Panel	*Substitute Panel*	*Effect On Operation*
PN-8-B	PN-8-A	Substitution not permitted because meter circuit will not be provided for PN-9-B and PN-10-B.
PN-8-A	PN-8-B	Satisfactory substitution; however, the meter switch will not be effective in three positions. Operation should be satisfactory without changing the interpanel wiring cable.
PN-9-B	PN-9-A	Satisfactory substitution; however, meter switch on PN-8-B will not be connected to oscillator panel and, therefore, will not be effective in two positions.
PN-9-A	PN-9-B	Not satisfactory. PN-9-B cannot be used with BC-640-A equipment unless PN-8-B is also used, because PN-9-B does not have the two meters used on PN-9-A.
PN-10-B	PN-10-A	Satisfactory substitution; however, meter switch on PN-8-B will not be effective in one position.
PN-10-A	PN-10-B	Not satisfactory. PN-10-B cannot be used with BC-640-A equipment unless PN-8-B is also used.
PN-13-B	PN-13-A	Satisfactory substitution, unless lock for variable transformer is desired.
PN-13-A	PN-13-B	Satisfactory substitution; no electrical changes.

LESSON PLAN No. 2

SUBJECT TIME ALLOTTED: 1½ HR.

General description.

OBJECTIVE

To describe the BC-640-B equipment.

8. For each assembly explain the following:
   a. Over-all dimensions.
   b. Installation and mounting details.
   c. Location and purpose of each control, switch, meter, and indicating lamp.
   d. Input and output characteristics.
   e. Location of protective devices.

f. Location and purpose of fuses.

g. Major physical differences of BC-640-A and BC-640-B units.

9. Describe the transmission line and antenna, and give the location of the output plug of the transmitter.

10. Interchangeability of panels.

CONCLUSIONS

Radio Transmitters BC-640-A and BC-640-B are alike except that in the BC-640-B the panels have dial locking devices, and all meters except two are omitted. The function of the meters omitted is accomplished by one meter, on the amplifier panel, through a five-position switch.

ORAL QUIZ

1. What are the input power requirements for this equipment?

2. What is the frequency range of the transmitter?

3. What is the nominal output of the transmitter?

4. Generally, how are the various panels removed from the cabinet?

5. What are the characteristics of the transmission line and antenna?

6. What are the eight major physical units?

7. Where are the remote telephone lines connected to the transmitter?

8. What is the purpose of the input transformer?

9. What is the purpose of the two power-supply panels?

10. How are crystals installed in the transmitter?

EXPERIMENT No. 1

SUBJECT

TIME ALLOTTED: 2 HR.

Physical identification.

OBJECTIVE

To become familiar with the physical characteristics of the BC-640-A and BC-640-B radio transmitter.

EQUIPMENT REQUIRED

Radio Transmitter BC-640-A or BC-640-B.

INSTRUCTIONS

It is very desirable that a sufficient number of equipments be available so that no more than two students may be required to work on each. In the interests of safety, the power supply should not be connected for this experiment.

PROCEDURE

1. List the major physical units, giving the official nomenclature and functional titles.

2. Make a pictorial sketch of the front of each panel. Label each control, switch, meter, knob, and indicating lamp with its reference symbol and functional title.

3. Open the rear door of the cabinet. Remove the panel below the door.

4. Draw a pictorial diagram of the cabinet terminal board and the input autotransformer.

5. Replace the panel.

6. Draw a series of plan sketches that illustrate the rear of each panel. Identify each clearly visible major component with its reference symbol and functional title.

CONCLUSIONS

1. What type of fuses are used throughout the equipment?

2. On what terminals of the power control panel are the 110-220-volt supply lines connected?

3. On what terminals are the output leads of the power supply connected?

4. On what panel is the MASTER H.V. switch located? What is its purpose?

5. Where is the plate-line shorting bar located?

6. Where is the REMOTE-LOCAL switch located?

7. On what terminal strip are the remote control lines connected?

8. Where does the coaxial transmission line enter the cabinet?

LECTURE No. 3

FUNCTIONAL BLOCK ANALYSIS

The functional block diagram of Radio Transmitter BC-640-B is shown in figure 18 and on Wall Chart No. 1. A study of this diagram will aid in understanding the over-all operation of the equipment.

The crystal oscillator is the source of radio-frequency oscillations. The output frequency of the oscillator is multiplied 18 times to obtain the desired output frequency of the transmitter. This multiplication is accomplished by the frequency-multipliers—the 1st and 2nd tripler stages, and the doubler stage. The fundamental crystal frequency (5555.5 kc. to 8666.6 kc.) is tripled by the 1st tripler. The output frequency of the 1st tripler (16.7 mc. to 26.0 mc.) is tripled by the 2nd tripler, and the output frequency of this stage (50 mc. to 78 mc.) is doubled by the doubler stage, to drive the intermediate power amplifier in the operating range of the transmitter.

The intermediate power amplifier (i.p.a.) develops approximately 15 watts of r-f energy, thus providing sufficient excitation for the inductively coupled power amplifier. The crystal oscillator, the frequency-multiplier stages, and the intermediate power amplifier are all physically located on the oscillator panel.

The power amplifier is tuned, and its output is coupled to the transmission line by circuit elements contained in the amplifier panel. This stage delivers approximately 50 watts of radio-frequency output to the transmission line.

Also contained on the amplifier panel is a monitor stage, which rectifies a small portion of the output signal and extracts the audio component. The monitor-tube current can be read on a meter directly, or the audio can be heard by inserting a headset in the jack at the bottom center of the panel. The audio can also be remotely monitored by connecting appropriate remoting lines to the equipment.

When the transmitter is operated on voice, the output of the microphone is fed to the input of the cathode-biased push-pull speech amplifier through the LOCAL-REMOTE switch and a coupling transformer. The LOCAL-REMOTE switch selects the speech input to the equipment. The output of the speech amplifier is coupled to the push-pull driver stage, which develops sufficient output to drive the modulator. A zero-bias class-B modulator is used. Its output provides the necessary audio power to modulate the power amplifier 100 per cent at all frequencies, with either voice or 1000-cycle input.

The audio oscillator produces a 1000-cycle tone, which is used to modulate the carrier when the transmitter is operated on MCW. Its output is coupled to the input of the speech amplifier through the keying relay. This oscillator and the keying relay are physically located on Modulator Panel PN-10-B.

The power control circuits compensate for the various line input voltages, and produce a constant output of 230 volts, a.c. These circuits provide a.c. for the filaments of the audio-frequency circuits and the radio-frequency circuits, and also provide a.c. for the power panels which supply the high voltages to the a-f and the r-f circuits, thereby effectively providing the high voltage.

Major test point ① checks the operation of the power-supply panels; major test point ② checks the output of the radio-frequency circuits, which are contained in the oscillator and amplifier panels; major test point ③ checks the audio-frequency circuits, which are contained in the modulator panel.

LESSON PLAN No. 3

SUBJECT TIME ALLOTTED: 1 HR.

Functional block analysis.

OBJECTIVE

To analyze the operation of the equipment by means of a functional block diagram.

INTRODUCTION

Radio Transmitter BC-640-B consists of three functional sections: the power-supply circuits, the radio-frequency circuits, and the audio-frequency circuits.

SUBJECT MATERIAL

1. Display Wall Chart No. 1.

2. Explain the function of the following radio-frequency circuits:
   a. Crystal oscillator.
   b. 1st tripler.
   c. 2nd tripler.
   d. Doubler.
   e. Intermediate power amplifier.
   f. Power amplifier.

3. Trace an r-f signal from the crystal oscillator to the antenna. Show effects of frequency multiplication on the fundamental crystal frequency.

4. Explain the function of the following audio-frequency circuits:
   a. Speech amplifier.
   b. Driver.
   c. Modulator.

5. Trace an a-f signal from the microphone input to the power amplifier.

6. Explain the function of the audio oscillator and the keying relay.

7. State the input and output voltages of the power-supply circuits.

(Continued on page 24)

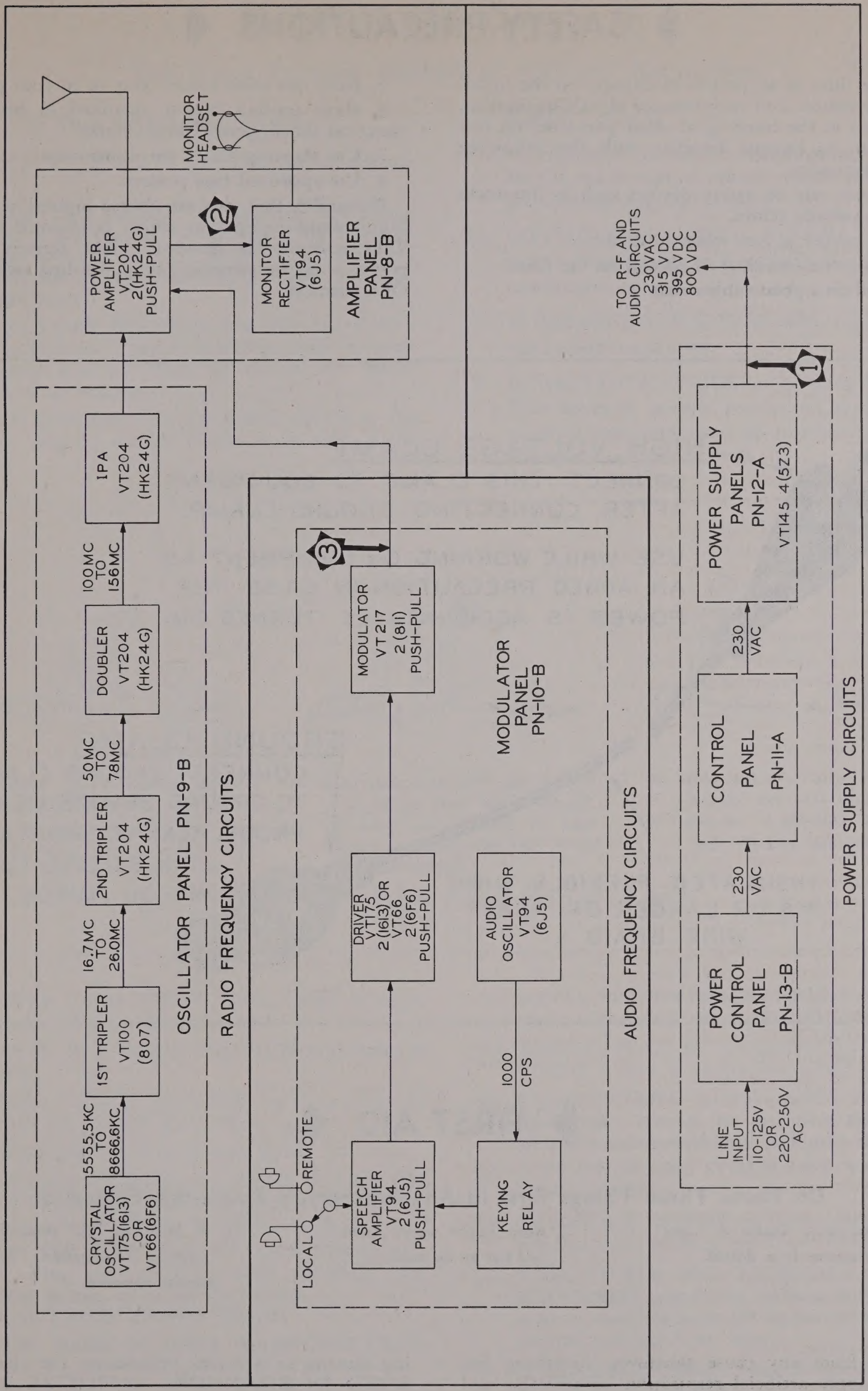

MONITOR HEADSET
POWER AMPLIFIER VT204 2(HK24G) PUSH-PULL
MONITOR RECTIFIER VT94 (6J5)
AMPLIFIER PANEL PN-8-B
②
CRYSTAL OSCILLATOR VT175(1613) OR VT66(6F6)
5555.5KC TO 8666.6KC
1ST TRIPLER VT100 (807)
16.7MC TO 26.0MC
2ND TRIPLER VT204 (HK24G)
50MC TO 78MC
DOUBLER VT204 (HK24G)
100MC TO 156MC
IPA VT204 (HK24G)
OSCILLATOR PANEL PN-9-B
RADIO FREQUENCY CIRCUITS
LOCAL
REMOTE
SPEECH AMPLIFIER VT94 2(6J5) PUSH-PULL
DRIVER VT175 2(1613) OR VT66 2(6F6) PUSH-PULL
MODULATOR VT217 2(811) PUSH-PULL
③
KEYING RELAY
1000 CPS
AUDIO OSCILLATOR VT94 (6J5)
MODULATOR PANEL PN-10-B
AUDIO FREQUENCY CIRCUITS
LINE INPUT 110-125V OR 220-250V AC
POWER CONTROL PANEL PN-13-B
230 VAC
CONTROL PANEL PN-11-A
230 VAC
POWER SUPPLY PANELS PN-12-A VT145 4(5Z3)
①
TO R-F AND AUDIO CIRCUITS 230VAC 315 VDC 395 VDC 800 VDC
POWER SUPPLY CIRCUITS
TP9-124

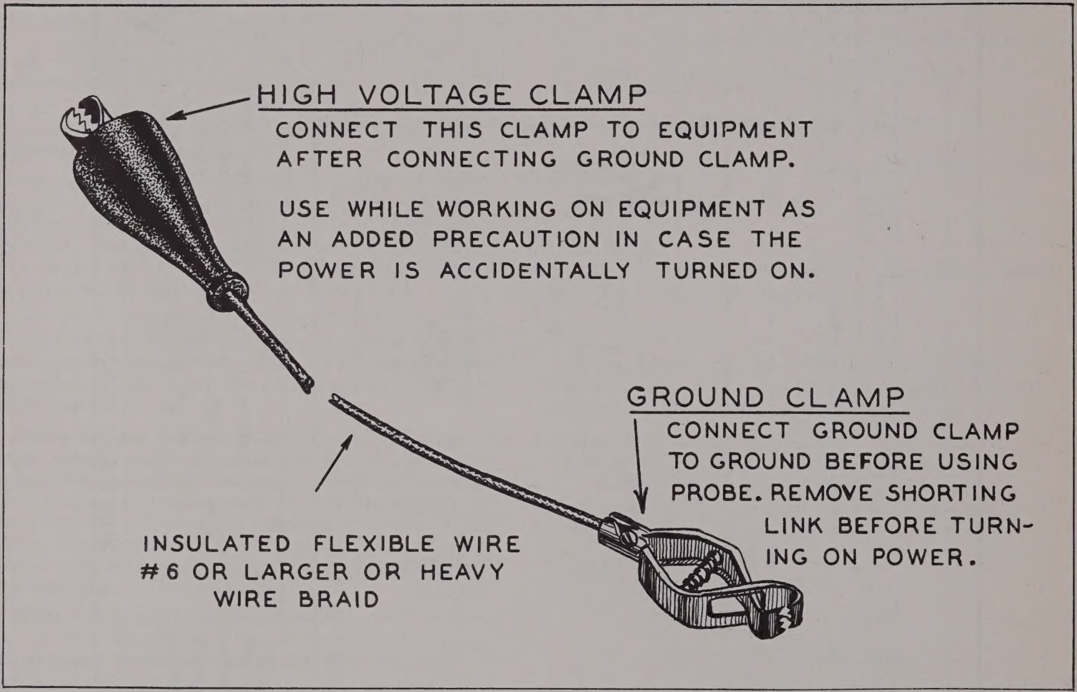
Figure 18. Functional Block Diagram of Radio Transmitters BC-640-A and BC-640-B

SAFETY PRECAUTIONS

It is the duty of all personnel engaged in the installation, operation, and maintenance of this equipment, or engaged in the training of other personnel on this equipment, to become familiar with the following safety precautions.

1. Do not rely on safety devices such as interlocks and high-voltage relays.
2. Use rubber gloves when in doubt.
3. Keep your feet clear of objects on the floor.
4. Stand on a good rubber mat.
5. Keep one hand behind you, or in your pocket.
6. Have another person, qualified in first aid for electrical shock, present at all times.
7. Use shorting link (see illustration).
8. Use approved fuse pullers.

Remember that men are always injured or killed by high-voltage equipment which is assumed to be off. Take nothing for granted. Make certain that the power is off by securing the power-line switch in its OFF position.


HIGH VOLTAGE CLAMP
CONNECT THIS CLAMP TO EQUIPMENT AFTER CONNECTING GROUND CLAMP.
USE WHILE WORKING ON EQUIPMENT AS AN ADDED PRECAUTION IN CASE THE POWER IS ACCIDENTALLY TURNED ON.
GROUND CLAMP
CONNECT GROUND CLAMP TO GROUND BEFORE USING PROBE. REMOVE SHORTING LINK BEFORE TURNING ON POWER.
INSULATED FLEXIBLE WIRE #6 OR LARGER OR HEAVY WIRE BRAID

TP-9692

FIRST AID

Do These Three Things First in Any Emergency Requiring First Aid

1. Send for a doctor or carry the victim to a doctor.
2. Keep victim warm, quiet, and flat on his back.
3. If breathing has stopped, apply artificial respiration. Stop all serious bleeding.

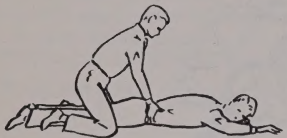
When, from any cause whatever, breathing has stopped, apply artificial respiration immediately and continue WITHOUT STOPPING until normal breathing returns, or a doctor pronounces the victim dead. SPEED IN BEGINNING ARTIFICIAL RESPIRATION IS ESSENTIAL.

FIRST AID (Cont.)

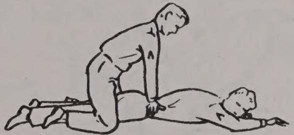
The Prone Pressure Method of Artificial Respiration

If Due to Electric Shock

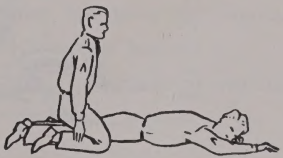
1. PROTECT YOURSELF with DRY insulating material.
2. BREAK THE CRCUIT by opening the power switch or pulling the victim free of the live conductor. DON'T TOUCH THE VICTIM WITH YOUR BARE HANDS UNTIL THE CIRCUIT IS BROKEN.
3. SPREAD DRY BLANKET ON THE GROUND, and roll victim to center of blanket with his arms extended over his head, so that he lies FACE DOWN on blanket.
4. BEND ONE OF THE VICTIM'S ARMS at the elbow and rest victim's cheek on the back of his hand.



(1) Straddle victim across thighs. Place the palms of your hands on the victim's back so that the little fingers of each hand just touch the victim's lowest ribs.



(2) Keep your arms stiff and straight and swing your body forward, allowing your weight to bear down on victim. DO NOT PUSH OR USE FORCE.



(3) Swing back at once to relieve pressure, and then continue the rhythmic application of alternate pressure and release.

Blanket is not shown in above drawings for the sake of clarity.

5. REMOVE FALSE TEETH, gum, candy, tobacco, food, etc., from victim's mouth.
6. LOOSEN ALL TIGHT CLOTHING, as belts or collars.
7. COVER VICTIM LOOSELY by wrapping the ends of the blanket around him.
8. STRADDLE VICTIM across thighs.
9. PLACE THE PALMS OF YOUR HANDS ON VICTIM'S BACK so that the little fingers of each hand just touch the victim's lowest ribs.
10. KEEP YOUR ARMS STIFF AND STRAIGHT and swing your body forward, allowing your weight to bear down on the victim.
11. DO NOT PUSH OR USE FORCE.
12. SWING BACK AT ONCE TO RELIEVE PRESSURE.
13. REPEAT Step 10.
14. REPEAT Step 12.
15. CONTINUE as above, maintaining a steady rhythm until victim regains consciousness or is pronounced dead by a doctor.
16. CONTINUE ARTIFICIAL RESPIRATION even after victim begins to breathe, and until he becomes conscious.
17. IF BREATHING STOPS AGAIN, continue artificial respiration at once.
18. DO NOT GIVE UP HOPE of reviving the victim. Four hours or more of continuous application of artificial respiration may be required before consciousness returns.
19. NEVER TRY TO FORCE LIQUIDS down an unconscious person's throat. He will drown.
20. ALWAYS WAIT UNTIL CONSCIOUSNESS RETURNS before administering liquid stimulants.
21. RECOMMENDED STIMULANTS ARE: Hot, black coffee. Strong, hot tea. Aromatic spirits of ammonia, one teaspoonful to a glass of water.
22. GIVE ONLY ONE STIMULANT, which should be sipped slowly.
23. ALCOHOLIC DRINKS are not recommended, unless absolutely nothing else is available.
24. When VICTIM HAS RETURNED TO CONSCIOUSNESS, allow him to lie quietly where he is for at least one hour, taking care that he is well covered and free from worry.
25. IF POSSIBLE, CARRY, OR HAVE HIM CARRIED TO A DOCTOR.

LESSON PLAN No. 3 (Cont.)

8. Describe the functions of the power-control circuits.

9. Point out the three major test points, and name the major functional unit which each one checks.

10. Review the high-voltage safety precautions and first aid for electrical shock.

CONCLUSIONS

By utilizing the three major test points, trouble can be localized to any one of the major functional units of the equipment.

ORAL QUIZ

1. What type of oscillator circuit is used?

2. What is the frequency range of the crystals?

3. How many times is the crystal frequency multiplied to produce the desired output frequency?

4. In what major physical assembly is the audio oscillator located?

5. What is the purpose of the keying relay?

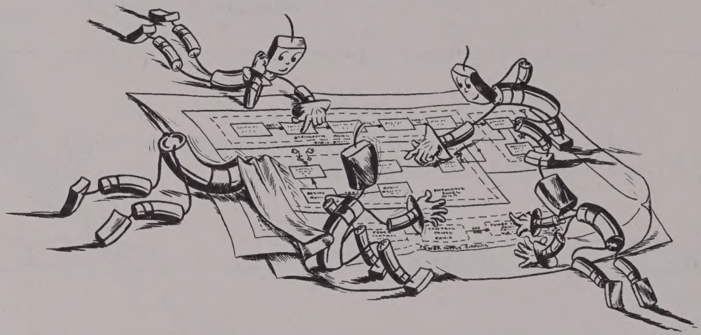
6. What is the purpose of the monitor rectifier?

7. What is the percentage modulation capability of this equipment?

8. What value of plate voltage is supplied to the audio-frequency circuits?

9. What value of plate voltage is supplied to the r-f circuits?

10. What major functional unit is tested at major test point 1 ? At major test point 2 ? At major test point 3 ?



EXPERIMENT No. 2

SUBJECT

TIME ALLOTTED: 2 HR.

Major test points in BC-640-B equipment.

OBJECTIVE

To become familiar with the locations of the major test points, and the normal indications that should be obtained at these test points.

EQUIPMENT REQUIRED

One or more Radio Transmitters BC-640-A or BC-640-B.

For each Transmitter:

Source of 60-cycle a-c, either 110 to 125, or 220 to 250 volts.

One d-c voltmeter with 1000-volt range.

One headset, with plug.

One single-button carbon microphone with plug.

INSTRUCTIONS

If not already accomplished, connect power-supply input lines to cabinet terminal board. Set POWER MAINS switch to OFF. Push PRESS OFF buttons of MASTER FILAMENTS and MASTER H. V. switches. Set LOCAL-REMOTE switch to REMOTE, and TUNE-OPERATE switch to TUNE. Set all switches under the cover on Control Panel to ON position. Make certain that both neutralizing links are in place.

PROCEDURE

1. Sketch a plan view of the transmitter.

2. Draw arrows on the sketch to show the path of the r-f signal.

3. Draw arrows on the sketch to show the path of the a-f signal when the equipment is operating on:

   a. Voice.

   b. MCW.

4. Major test point 1 is located at terminal 17 on the rear of the upper and lower power-supply panels. Connect positive lead of d-c voltmeter (1000-volt scale) to test point on lower power-supply panel; connect negative lead to terminal 14. Operate POWER

MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H. V. switch. Depress interlock switch and set TUNE-OPERATE switch to OPERATE. Momentarily set LOCAL-REMOTE switch to LOCAL. The d-c voltmeter should read 780 to 850 volts, indicating that the lower power-supply panel is operating normally. Push PRESS OFF buttons of MASTER FILAMENTS and MASTER H. V. switches. Operate POWER MAINS switch to OFF position. Disconnect meter leads.

5. Using the procedure given in step 4, test the output of the upper power-supply panel. The d-c voltmeter should read 780 to 850 volts.

6. Major test point ② is located at the M.A. CURRENT meter on the amplifier panel. (For Radio Transmitter BC-640-A, it is located at the GRID CURRENT meter on the amplifier panel.) Set POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENT switch. Wait one minute and then push PRESS ON button of MASTER H. V. switch. The interlock switch must be in the closed position. Set TUNE-OPERATE switch to OPERATE. Set METER RANGE MILLIAMPERES SWITCH to PA-G, and G1-G2-MON. switch to MON. Set LOCAL-REMOTE switch to LOCAL. The M.A. CURRENT meter should read more than 1 ma., indicating that the r-f circuits are functioning properly. Set LOCAL-REMOTE switch to REMOTE.

7. Major test point ③ is located at the M.A. CURRENT meter on the amplifier panel. (For Radio Transmitter BC-640-A, this test point is located at the MODULATOR ANODE CURRENT meter on the front of the modulator panel.) Plug headset into MONITOR jack. Plug microphone into MICROPHONE NO. 1 jack. Set METER RANGE MILLIAMPERES switch to MOD. Set LOCAL-REMOTE switch to LOCAL. Talk into microphone. The M.A. CURRENT should read 40 ma. at no signal, and approximately 108 ma. on voice peaks. Voice should be heard in headset. These indications prove that the audio-frequency circuits are functioning. Press PUSH OFF buttons of MASTER FILAMENT and MASTER H. V. switches. Operate POWER MAINS switch to OFF.

CONCLUSIONS

1. Name the functional blocks that are probably at fault if abnormal indications are obtained at:
   a. Major test point ① .
   b. Major test point ② .
   c. Major test point ③ .

2. Where is major test point ① physically located? Where is it electrically located?

3. Where is major test point ② physically located? Where is it electrically located?

4. Where is major test point ③ physically located? Where is it electrically located?

LECTURE No. 4

ANALYSIS OF CRYSTAL-OSCILLATOR CIRCUIT

The crystal oscillator is the source of radio-frequency oscillations for the transmitter. It is a tuned-plate crystal-controlled oscillator and functions only as a frequency-generating device. This type of circuit is used to obtain the high frequency stability that is characteristic of an oscillator which is controlled by a piezo-electric crystal. Since the crystal will oscillate only over a very narrow range at its resonant frequency, the frequency is maintained at a certain definite value. Essentially this stage is similar to a tuned-plate tuned-grid oscillator, with the crystal functioning as the parallel resonant circuit in place of the usual 1-c grid-tank.

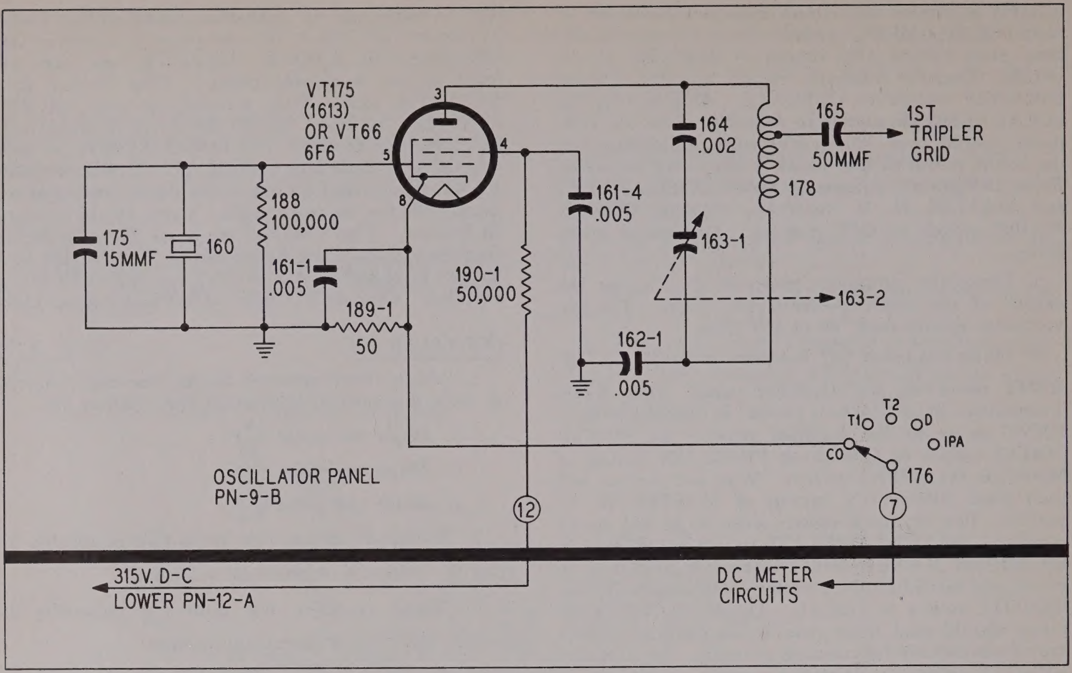
The oscillator is shown in block form in figure 18, and in schematic form in figure 19.

Vacuum tube VT175 (commercial type 1613) or VT66 (commercial type 6F6) is used in the oscillator circuit. The operating characteristics of these tubes are virtually identical. Feed-back to the crystal takes place through the grid-to-plate capacitance of the tube.

Standard plug-in-type piezo-electric crystals (Signal Corps type CR-1A/AR), which are inserted in a three-prong special socket from the front of the oscillator panel, are used. (See figure 11.) The frequency range of the crystals is 5555.5 kc. to 8666.6 kc. The frequency of each crystal is stamped on the crystal-housing cover. For this transmitter the required crystal frequency may be determined by dividing the desired transmitter output frequency, in kilocycles, by 18. Similarly, the output frequency of the transmitter in kilocycles may be determined by multiplying the crystal frequency by 18. In either case the resultant frequency may be converted to megacycles simply by dividing by 1000, since one megacycle equals 1000 kc.

The zero-temperature-coefficient capacitor, 175, in parallel with the crystal, is used to make the effective crystal input capacitance the same as that of aircraft Radio Set SCR-522, which is generally used in aircraft stations as a part of the communication system in which the BC-640-B is employed. Thus, the crystals for these two equipments may be interchanged.

The operating bias for the grid is developed across resistor 188. The cathode is by-passed to ground through the low-impedance r-f path offered by capacitor 161-1. An indication of direct current in the cathode circuit is provided by meter 139 when the cir-


VT175
(1613)
OR VT66
6F6
3
5
4
8
188
100,000
175
15MMF
160
161-1
.005
189-1
50
190-1
50,000
161-4
.005
164
.002
163-1
163-2
162-1
.005
178
165
50MMF
1ST
TRIPLER
GRID
T2
T1
D
IPA
CO
176
7
12
OSCILLATOR PANEL
PN-9-B
315V. D-C
LOWER PN-12-A
DC METER
CIRCUITS

TP-9685

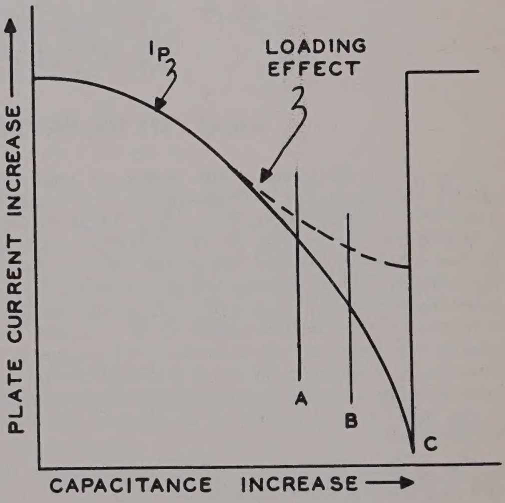
Figure 19. Crystal-Oscillator Circuit

cuits are properly connected by switch 176. Resistor 189-1 is used to complete the cathode circuit to ground when the meter is disconnected from the circuit.

The filaments are by-passed to ground for r-f by capacitors 161-2 and 161-3, and are heated by a 6.3-volt potential from the secondary winding of transformer 196.

Inductor 178 and capacitors 164 and 163-1 comprise the plate-tank circuit. Capacitor 163-1, which functions as the plate-tuning capacitor, is mechanically coupled to the CO/T1 dial on the front of the oscillator panel. As the value of this capacitance is increased, the plate current slowly decreases. This behavior is shown by the graph in figure 20. Oscillations occur when the plate current is minimum, as indicated by point C on the graph. This point is the resonant frequency of the crystal, and it is the critical point in the operation of the oscillator. When the oscillator is placed under load, the plate-current dip is less pronounced, as shown by the dotted line on the graph. The greater the load, the smaller is the dip in plate current. (If the load is too great, oscillations will not occur.) For most stable oscillation, and less likelihood that a slight change in loading will cause the circuit to stop oscillating, the plate should be tuned to a frequency slightly higher than the resonant frequency of the crystal. This point is in the A-B region on the graph, and will be determined by the loading effect. Capacitor 164 functions as a band-spread capacitor.

The plate of the tube is supplied with 315 volts, d.c., through plate inductor 178. Voltage for the screen grid is obtained from the plate-voltage supply, and is dropped to 150 volts, d.c., by the series dropping resistor, 190-1. The screen is at ground potential for radio-frequency and has no part in the operation of the



TP-9681

Figure 20. Typical Behavior of Plate Current in Crystal-Oscillator Circuit

circuit other than to set the operating characteristics of the tube. The screen-grid by-pass capacitor, 161-4, and the plate-circuit by-pass capacitor, 162-1, offer a low-impedance r-f path to ground for the screen grid and the plate.

The M.A. CURRENT meter on the amplifier panel is the secondary test point, (E1) for the crystal oscillator. For Radio Transmitter BC-640-A, the CATHODE CURRENT meter on the oscillator panel is the secondary test point.

LESSON PLAN No. 4

SUBJECT

TIME ALLOTTED: ½ HR.

Analysis of crystal-oscillator circuit.

OBJECTIVE

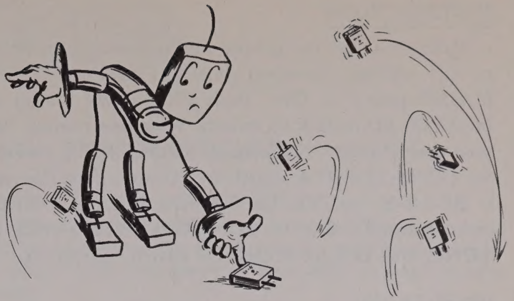
To analyze the crystal-oscillator circuit

INTRODUCTION

The crystal oscillator is the source of radio-frequency oscillations for the transmitter.

SUBJECT MATERIAL

1. Display Wall Chart No. 1, and review the function of the crystal oscillator.
2. Display Wall Chart No. 2, and draw figure 19 on the blackboard.
3. State the type of oscillator circuit, and the reason that it is used.
4. State the types of vacuum tubes that may be used.
5. Describe the crystals and give the frequency range.
6. Explain how the crystal and operating frequencies may be computed.
7. Explain the functioning of capacitor 175.
8. Trace the cathode circuit to ground.
9. Explain how grid bias is developed.
10. Describe the plate and screen-grid circuits.
11. Point out the capacitor which couples the oscillator r-f output to the 1st tripler.



12. Draw figure 20 on the blackboard.
13. Show the effect of loading, and explain why operation is desirable in the A-B region of the graph.
14. Point out the secondary test point in the circuit and explain its use.

CONCLUSIONS

Trouble in the oscillator circuit may be detected and isolated by the use of one secondary test point. The defective component, or group of components, may then be located by the use of additional resistance and voltage measurements.

ORAL QUIZ

1. What type of oscillator circuit is employed in the transmitter?
2. How is the output frequency, in megacycles, determined when the crystal frequency is known?
3. How is the crystal frequency, in megacycles, determined when the output frequency is known?
4. What is the purpose of the CO/T1 dial, with reference to the oscillator circuit?
5. Why is the oscillator plate tank tuned to a frequency slightly higher than the resonant frequency of the crystal?
6. At what r-f potential is the screen grid operated?

EXPERIMENT No. 3

SUBJECT

TIME ALLOTTED: 1½ HR.

Tuning and trouble shooting the crystal-oscillator circuit.

OBJECTIVE

To become familiar with the methods of tuning the crystal oscillator, isolating trouble within the circuit through the use of a secondary test point and locating defective components by means of additional resistance and voltage checks.

EQUIPMENT REQUIRED

One or more Radio Transmitters BC-640-B or BC-640-A.

For each transmitter:

One suitable antenna (or dummy).

One d-c voltmeter with 500-volt range.

One a-c voltmeter with 10-volt range.

One ohmmeter.

INSTRUCTIONS

Make sure that the proper input power is available to the cabinet terminal board. Operate POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H.V. switch. Set CO-T1-T2-D-IPA switch to CO and, if equipment is BC-640-B, set METER RANGE MILLIAMPERES switch to EXC-C. Set TUNE-OPERATE switch to TUNE, and LOCAL REMOTE switch to LOCAL.

PROCEDURE

1. Note frequency of the crystal in socket 160. Refer to calibration chart on oscillator panel and note proper setting of CO/T1 control for the crystal in use. Unlock CO/T1 control, if equipment is BC-640-B, and rotate control to the 0 point on vernier scale. Observing action of M.A. CURRENT meter pointer, test point E1 , slowly increase capacitance by rotating the CO/T1 control in a counterclockwise direction. Tune for minimum current, which indicates resonance in the plate tank circuit. Set TUNE-OPERATE switch to OPERATE. Adjust the CO/T1 control for an increase of 3-5 ma. in the meter reading. At this setting of the control the oscillator is in its most stable operating condition. The meter indication should be 30 to 40 ma. Operate LOCAL-REMOTE switch to REMOTE, and POWER MAINS switch to OFF.

2. Open rear door of equipment. Remove interpanel wiring harness from rear of oscillator panel. Remove the eight mounting screws from front of panel, and lift panel from rack. Support it at rear of cabinet and attach wiring to terminal strip. Extend wiring if necessary by attaching the necessary length of wire between terminal stud and soldering lug on wiring harness. Tape joints as necessary. Set POWER MAINS switch to ON, and LOCAL-REMOTE switch to LOCAL. Depress interlock switch.

WARNING—HIGH VOLTAGE IS PRESENT IN THE OSCILLATOR PANEL AND THROUGHOUT THE EQUIPMENT.

3. Connect negative lead of d-c voltmeter to terminal 11 of terminal strip, and positive lead to terminal 12. The meter should indicate 300 to 330 volts, which is the correct plate supply voltage for the oscillator tube.

4. Using the a-c and d-c voltmeters, measure the voltages between the pins of the oscillator-tube socket and ground. Complete CHART A.

5. Operate POWER MAINS switch to OFF. Set CO-T1-T2-D-IPA switch to T1. Remove wiring harness from terminal-strip assembly. Remove oscillator tube VT1613, or VT66, from socket. Using appropriate range of ohmmeter, make the measurements necessary to complete CHART B. Make all measurements from socket pin to ground unless otherwise stated.

6. The instructor will simulate trouble in the oscillator circuit. Locate the defect by using the procedure outlined in this experiment.

NOTE: The transmitter will not function properly with the oscillator panel mounted in any position other than its normal one in the rack.

CONCLUSIONS

1. What test point will isolate trouble to the oscillator circuits?

2. What is the probable cause of trouble if a high or infinite resistance is measured between pin 5 of the oscillator-tube socket and ground?

3. If the indication at test point E1 is abnormally high and if the reading remains constant while the CO/T1 control is varied, what are two probable causes of trouble?

4. If an infinite resistance reading is obtained between pins 2 and 7 on the oscillator-tube socket, what is the probable cause of trouble?

CHART A

Pin No.	*Voltage*	*Circuit*
3		
4		
5		
8		
2		
7		

CHART B

Pin No.	*Resistance*	*Circuit*
3		
4		
5		
8		
Between 3 and 4		
2		
Between 2 and 7		

LECTURE No. 5

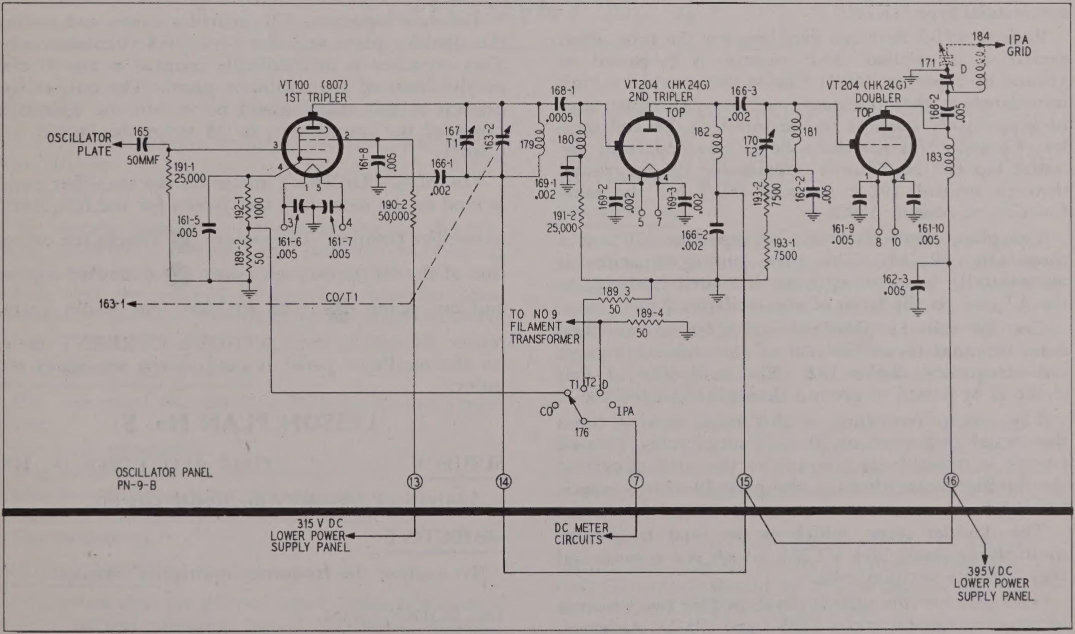
ANALYSIS OF FREQUENCY-MULTIPLIER CIRCUITS

Frequency-multiplier circuits are necessary since it is desired to operate the transmitter in a frequency range much higher than the highest possible frequency obtainable from a crystal. The circuits used are essentially overdriven class-C radio-frequency amplifiers, with the plate-tank circuits tuned to resonate at either a second or third harmonic, rather than at the fundamental frequency of the grid tank. Thus an effective multiplication of the input frequency occurs. Class-C operation is used, because greater efficiency is obtained when the tubes are operated at high grid bias. When the plate circuit is tuned to the second harmonic, the stage is called a frequency doubler; when the plate circuit is tuned to the third harmonic, the stage is called a frequency tripler. The transmitter uses two frequency-tripler stages and one frequency-doubler stage to provide excitation for the intermediate power amplifier, at 18 times the crystal frequency in the operating range of the transmitter. Since the input and output frequencies are different, neutralization is not necessary.

These circuits are shown in block form in figure 18 and Wall Chart No. 1, and in schematic form in figure 21.

The 1st tripler, which functions as a frequency tripler at all times, is the first frequency-multiplying stage. Tube VT100 (commercial type 807) is used in this stage.

Radio-frequency energy is capacitively coupled from the tuned-plate circuit of the crystal oscillator to the grid circuit of the 1st tripler. The coupling capacitor (165) functions as a blocking capacitor to isolate the d-c oscillator plate voltage from the 1st-tripler grid circuit. Since VT100 is a beam-power tube, little excitation is required to drive the grid and, hence, the center tap on the oscillator plate coil (178) may be used for coupling, to aid in preventing any loading effect on the plate circuit of the crystal oscillator and thus reduce the possibility of the oscillator becoming unstable. Grid bias is developed through resistor 191-1 when excitation is applied. The value of this resistance is several times higher than that which would be used with the same tube operating as a conventional class-C r-f amplifier. Cathode bias, which is developed by resistor 192-1, prevents the tube from being damaged if the grid excitation fails by keeping the plate dissipation within the rating of the tube. Resistor 189-2 is used to complete the cathode circuit to ground


VT100 (807)
1ST TRIPLER
OSCILLATOR PLATE
165
50MMF
191-1
25,000
161-5
.005
192-1
1000
189-2
50
1
5
3
4
2
161-6
.005
161-7
.005
161-8
.005
190-2
50,000
166-1
.002
167
T1
163-2
179
163-1
CO/T1
168-1
.0005
180
169-1
.002
191-2
25,000
VT204 (HK24G)
2ND TRIPLER
TOP
169-2
.002
169-3
.002
5
7
182
166-2
.002
166-3
.002
170
T2
181
193-2
7500
193-1
7500
162-2
.005
VT204 (HK24G)
DOUBLER
TOP
161-9
.005
8
10
161-10
.005
183
168-2
.005
171
D
184
IPA GRID
162-3
.005
189 3
50
189-4
50
TO NO 9 FILAMENT TRANSFORMER
T1
T2
D
CO
IPA
176
13
14
7
15
16
OSCILLATOR PANEL
PN-9-B
315 V DC
LOWER POWER SUPPLY PANEL
DC METER CIRCUITS
395 V DC
LOWER POWER SUPPLY PANEL

TP-9688

Figure 21. Frequency-Multiplier Circuits

when the d-c meter circuits are disconnected. The cathode is by-passed to ground through the low-impedance r-f path offered by capacitor 161-5.

Resistor 190-2 drops the 315 volts, d.c. supplied to terminal 13 to 150 volts for the screen grid. This grid is by-passed to ground by the low-impedance r-f path offered by capacitor 161-8.

The 395-volt d-c plate voltage is fed through the plate-inductor coil (179), from terminal 14 on the rear of the chassis. The plate is by-passed to ground by capacitor 166-1. When the TUNE-OPERATE switch on the control panel is set to the TUNE position, the value of the plate voltage is halved.

Inductor 179 and capacitors 163-2 and 167 comprise the tuned-plate tank circuit. The plate tuning capacitor (163-2), which varies the resonant frequency of the plate tank circuit, is mechanically coupled with an insulated bushing to the shaft of the oscillator plate tuning capacitor (163-1), and the CO/T1 dial on the front of Oscillator Panel PN-9-B. This dial is graduated so that tuning is easily and quickly accomplished, with little possibility of tuning to the wrong harmonic.

Trimmer capacitor 167, in parallel with the plate tuning capacitor, is mechanically coupled with control knob T1 on the front of the oscillator panel. This capacitor functions as a band-spread capacitor, and provides a means of fine checking the tuning of the plate-tank circuit.

The output of this stage is capacitively coupled to the grid of the 2nd tripler. Coupling capacitor 168-1 isolates the d-c plate voltage from the grid circuit of the 2nd tripler.

The 2nd tripler functions as a frequency tripler at all times, and employs tube VT204, which is the commercial type HK24G.

Resistor 191-2 develops grid bias for the tube when excitation is applied. This resistor is by-passed to ground by capacitor 169-1. Choke 180 provides a high impedance so that the output of the 1st tripler may be capacitively coupled to the input of the 2nd tripler. Cathode bias for the tube is obtained from the center tap (6) of filament transformer 196 to ground through resistor 192-2. Resistor 189-3 has the same function as resistor 189.2.

The plate circuit is tuned by capacitor 170 and a three-turn coil, 181. This plate tuning capacitor is mechanically coupled, with an insulated bushing, to the T2 dial on the front of the oscillator panel.

The 395-volt d-c plate voltage is fed to the plate from terminal 15, at the rear of the chassis, through radio-frequency choke 182. The cold side of this choke is by-passed to ground through capacitor 166-2.

The output frequency of this stage is nine times the crystal frequency, or 50 to 78 megacycles. This r-f energy is capacitively coupled to the grid circuit of the doubler stage, through the plate blocking capacitor 166-3.

The doubler stage, which is the final frequency-multiplying stage, uses VT204, which is a commercial type HK24G vacuum tube.

Grid bias for this tube is developed by two resistors of the same value in series (193-1 and 193-2). Although very little power is dissipated by these two resistors, 2-watt values are used to maintain the same standard for all resistors throughout the equipment. Capacitor 162-2 is an r-f by-pass for these resistors. Cathode bias is not required for this tube since the plate voltage is only 395 volts, d-c., which allows the tube to operate within its rated dissipation at zero grid bias.

Plate voltage is shunt fed from terminal 16, at the rear of the chassis, through radio-frequency choke 183. The choke is by-passed to ground, on the input side, by capacitor 162-3.

Capacitor 168-2 is a plate blocking capacitor, which prevents d-c voltage from entering the grid circuit of the i.p.a. The plate-tank circuit is composed of one-half of inductor 184 and one-half of the dual variable capacitor, 171. These elements comprise the plate load, which is transformer-coupled to the input of the i.p.a. Figure 22 shows a simplified diagram of the coupling circuits.

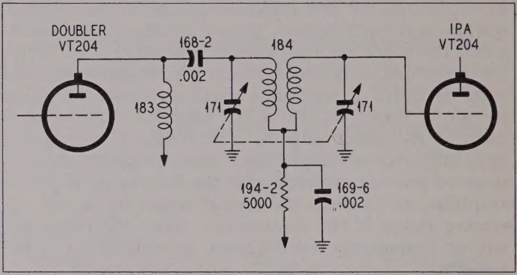


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Figure 22. Coupling to Intermediate-Power-Amplifier Circuits

The dual capacitor, 171, provides a means of tuning the doubler plate and the i-p-a grid simultaneously. This capacitor is mechanically coupled to the D dial on the front of the oscillator panel. The output frequency of this stage should be within the operating range of the transmitter, or 18 times the crystal frequency.

The M.A. CURRENT meter on the amplifier panel is used as the secondary test points for the frequency-multiplier circuits. Test point E 2 checks the operation of the 1st tripler; test point E 3 , the 2nd tripler; and test point E 4 , the doubler. For Radio Transmitter BC-640-A, the CATHODE CURRENT meter on the oscillator panel is used as the secondary test point.

LESSON PLAN No. 5

SUBJECT TIME ALLOTTED: 1¼ HR.

Analysis of frequency-multiplier circuits.

OBJECTIVE

To analyze the frequency-multiplier circuits.

INTRODUCTION

Frequency-multiplier circuits are necessary since it is desired to operate the transmitter in a frequency range much higher than the highest possible frequency obtainable from a crystal.

SUBJECT MATERIAL

1. Display Wall Chart No. 1, and briefly describe the operation of the frequency-multiplier circuits.

2. Display Wall Chart No. 2, and point out the frequency-multiplier circuits on the schematic diagram.

3. For each stage, give the function of the stage and the circuits and components within the stage, and discuss the input and output characteristics. Draw figure 22 on the blackboard when discussing the coupling between the doubler and i.p.a.

4. Point out the secondary test points for each stage.

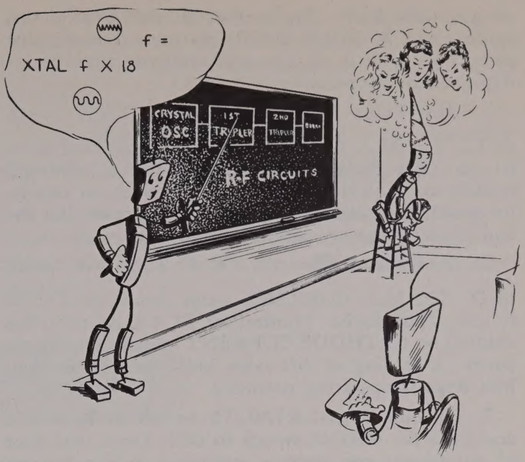
CONCLUSIONS

An inoperative condition of any one of the frequency-multiplier stages may be detected by the use of the secondary test point designated for that stage. The defective component, or group of components, may then be located through the use of additional voltage and resistance measurements.

ORAL QUIZ

1. State the input and output frequency range of each multiplier stage.

2. Where is test point E2, and what stage does it check?



3. Assuming that normal indications are observed at test points E1 and E2, what is the next logical test point to check?

4. What type of coupling is used for the input of each frequency-multiplier stage?

5. Would the transmitter operate normally if resistor 193-1 were shorted?

EXPERIMENT No. 4

SUBJECT

TIME ALLOTTED: 2 HR.

Tuning and trouble shooting the frequency-multiplier circuits.

OBJECTIVE

To become familiar with the tuning of the frequency-multiplier circuits, the method of isolating trouble within the circuits by means of secondary test points, and the method of locating defective components by means of resistance and voltage measurements.

EQUIPMENT REQUIRED

One (or more) BC-640-A or BC-640-B Radio Transmitter.

For each transmitter:
One suitable antenna (or dummy).
One d-c voltmeter with 500-volt range.
One a-c voltmeter with 10-volt range.
One ohmmeter.

INSTRUCTIONS

Make sure that the proper input power is available to the cabinet terminal board. Operate POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Set TUNE-OPERATE switch to OPERATE, and LOCAL-REMOTE switch to LOCAL.

PROCEDURE

1. Operate METER RANGE MILLIAMPERES switch to EXC-C. In the following steps, take meter readings from M.A. CURRENT meter on amplifier panel. (For Radio Transmitter BC-640-A, take meter readings on CATHODE CURRENT meter on oscillator panel.) Set CO-T1-T2-D-IPA switch to T1. Unlock T1 control and tune for minimum indication on M.A. CURRENT meter.

2. Set CO-T1-T2-D-IPA switch to T2. Unlock T2 control and tune for minimum meter indication. The T2 dial should read within 15 divisions of dial CO/T1. A greater variation indicates that dial T2 is tuned to the wrong harmonic.

3. Set CO-T1-T2-D-IPA switch to D. Unlock D control and tune for minimum meter indication. The dial D reading should be approximately the same as that of the T2 dial. Lock all dials.

4. Test Point E2 : Set CO-T1-T2-D-IPA switch to T1. The M.A. CURRENT meter should read 30 to

40 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.) A reading of this value indicates that the 1st tripler stage is operating normally.

5. Test Point E3 : Set CO-T1-T2-D-IPA switch to T2. The M.A. CURRENT meter should read 45 to 60 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.) A reading of this value indicates that the 2nd tripler stage is operating normally.

6. Test Point E4 : Set CO-T1-T2-D-IPA switch to D. The M.A. CURRENT meter should read 55 to 65 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel. A reading of this value indicates that the doubler stage is operating normally.

7. Operate LOCAL-REMOTE switch to REMOTE and POWER MAINS switch to OFF. Open rear door of equipment and remove interpanel wiring harness from rear of oscillator panel. Remove eight mounting screws from front of panel, and lift panel from rack. Support it at rear of cabinet and reattach wiring to terminal strip. Extend wiring as necessary by attaching the required length of wire between terminal stud and soldering lug on wiring harness. Tape joints as necessary. Set POWER MAINS switch to ON, and LOCAL-REMOTE switch to LOCAL. Depress interlock switch.

WARNING: HIGH VOLTAGE IS PRESENT IN THE OSCILLATOR PANEL AND THROUGHOUT THE EQUIPMENT.

8. Connect negative lead of d-c voltmeter to terminal 11. Make the measurements necessary to complete CHART A, by connecting the positive lead of the voltmeter to the terminal stud designated.

CHART A

STUD NO.	VOLTAGE	CIRCUIT SUPPLIED
13		
14		
15		
16		

9. Make the necessary voltage measurements to complete CHART B. Use an a-c voltmeter, 10-volt scale, to check the filament circuits. Use a d-c voltmeter for the other measurements. All measurements are to be made from the tube-socket pins to ground.

CHART B
1ST TRIPLER

PIN NO.	RESISTANCE	CIRCUIT
Plate cap		
2		
3		
4		
1		
5		

CHART B (Cont.)
2ND TRIPLER

PIN NO.	RESISTANCE	CIRCUIT
Plate cap (top of tube)		
Grid cap (side of tube)		
1		
4		
DOUBLER		
Plate cap (top of tube)		
Grid cap (side of tube)		
1		
4		

10. Operate POWER MAINS switch to OFF, and remove wiring harness from terminal-strip assembly. Remove frequency-multiplier tubes from sockets. To remove VT204, loosen setscrews and remove plate and grid leads. Push down on both high sides of spring ring, and lift tube straight up. To remove VT100, remove plate lead from top cap, move handle of tube clamp to right, and draw tube straight up.

11. Using an ohmmeter, make the necessary resistance measurements to complete CHART C. All measurements are to be made from the tube-socket pins to ground unless otherwise stated.

CHART C
1ST TRIPLER

PIN NO.	RESISTANCE	CIRCUIT
Plate lead		
2		
3		
4		
1		
Between 1 and 5		
2ND TRIPLER		
Plate lead		
Grid lead		
Between 1 and 4		
DOUBLER		
Plate lead		
Grid lead		
1		
Between 1 and 4		

Note: In replacing grid and plate leads of VT204, tighten the setscrews only enough to secure the cap in position.

12. The instructor will simulate trouble in the frequency-multiplier circuits. Locate the defect by using the procedure outlined in this experiment.

Note: The transmitter will not function properly if the oscillator panel is mounted in any other position than its normal one.

CONCLUSIONS

1. If the filament of one tube is open, how is the operation of the other tube filaments affected?

2. If the power-supply circuits are operating normally, but there is no indication of d-c voltage at terminal 13, what is the most probable cause of trouble?

3. If capacitor 170 were shorted, what would be the effect on the indication at test point E3 ?

4. If an indication of 25,000 ohms is observed on an ohmmeter connected from the plate of the 1st tripler to ground, what is the most probable cause of trouble?

LECTURE No. 6

ANALYSIS OF INTERMEDIATE-POWER-AMPLIFIER CIRCUITS

The intermediate-power-amplifier (i-p-a) stage, using a VT204 tube (commercial type HK24G), provides approximately 15 watts of radio-frequency energy to drive the power amplifier in the operating range of the transmitter. This stage is used since the output of the frequency-multiplier stages is insufficient to provide excitation to the final. The i-p-a circuit is shown in figure 23.

The doubler output, the frequency of which is 18 times the crystal frequency, is transformer-coupled to the input of the grid circuit. A simplified diagram of the coupling circuit is shown in figure 22. One-half of inductor 184 and one section of the dual capacitor, 171, comprise the tuned-grid input. Bias is developed by the two series resistors, 194-1 and 194-2, through the center tap of inductor 184. The two resistors 194-1 and 194-2 have the same resistance, and 2-watt values are used to maintain the same 2-watt standard for all resistors throughout the equipment. These resistors are by-passed to ground by the low-impedance path provided by capacitor 169-6. Resistor 189-6 is used to complete the grid circuit to ground when the d-c meter circuits are disconnected by switch 154.

The filaments are by-passed for r-f by capacitors 169-4 and 169-5, and are heated by a 6.3-volt potential derived from a secondary winding of filament transformer 196.

The plate-tank circuit uses a transmission-line-type tank coil, 185. This assembly is constructed of a ¼-inch (outside diameter), silver-plated copper tubing, 15 inches long, which is bent to form a "U". The unit is rigidly mounted so that it is mechanically stable, thereby reducing possible frequency changes from vibrations. The dual variable capacitor, 172, which functions as the plate tuning capacitor, is mechanically coupled to the IPA dial on the front of the oscillator panel. When the panel is fixed in its position in the cabinet, the i-p-a plate-tank coil is in parallel with the grid-tank coil of the power amplifier; therefore, the two coils are inductively coupled. A shield along the side of the oscillator panel prevents any stray r-f fields.

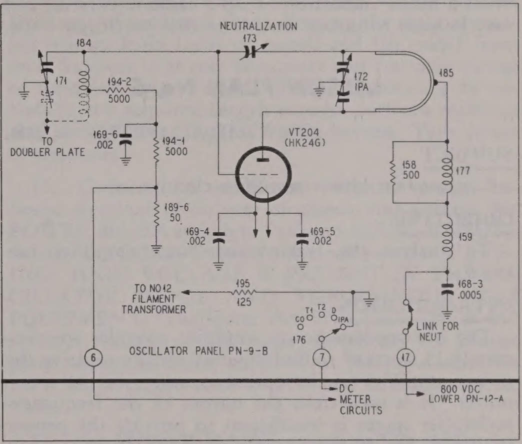


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Figure 23. Intermediate-Power-Amplifier Circuits

Plate voltage (800 volts, dc) is provided to terminal 17 at the rear of the chassis. The value of this voltage is reduced to one-half when the TUNE-OPERATE switch is in the TUNE position. The plate voltage is fed through a neutralizing link and two radio-frequency chokes (159, 177) to the center tap of the plate-tank coil. Choke 159 is used to prevent r-f feedback to the modulator circuit. The additional r-f choke which is shunted by resistor 158 functions as a parasitic suppressor. Capacitor 168-3 is the plate-choke by-pass.

The grid and plate circuits are physically located so that no interaction, which causes undesirable feedback, exists between them. Plate neutralization is used to prevent feedback through the grid-to-plate capacitance of the triode tube. Neutralizing capacitor 173 provides a separate r-f feedback from the plate to grid. By varying the value of this capacitance until the voltage feedback to the grid is equal, but of opposite phase, to the voltage feedback through the grid-to-plate capacitance, the two voltages will cancel. The neutralizing capacitor is mechanically coupled with an isolantite and bakelite coupler to the NEUT control on the front of the oscillator panel. Provision is made for removing the high plate voltage during the neutralizing procedure, by removing the neutralizing link from the rear of the chassis.

Since the grid resistors do not develop a bias voltage when the excitation is removed, filament bias is provided to prevent the rated plate dissipation of the tube from being exceeded. This bias is developed by plate current flow through resistor 195, which is connected from the filament center tap to ground. Resistor 189-5 has the same function as resistor 189-6.

Key test point E is the meter, which provides an indication of the combined grid and plate current of the i.p.a. A check at this test point indicates the over-all operation of the i.p.a. and the other r-f stages on the oscillator panel. Secondary test point E 5, provides a meter indication of i-p-a cathode current, and may be used to isolate trouble to that particular stage.

LESSON PLAN No. 6

TIME ALLOTTED: ¾ HR.

SUBJECT

Intermediate-power-amplifier circuits.

OBJECTIVE

To analyze the intermediate-power-amplifier circuits.

INTRODUCTION

The intermediate-power-amplifier provides approximately 15 watts of radio-frequency energy to drive the power amplifier in the operating range of the transmitter. It is used since the output of the frequency-multiplier stages is insufficient to provide the proper excitation for the final amplifier.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 and briefly review the action of the i.p.a.
2. Display Wall Chart No. 2 and point out the i-p-a circuits.
3. State the type of circuit and vacuum tube used in the i.p.a.
4. Draw figure 22 on the blackboard. Describe the input circuit and give the function of the components associated with this circuit.
5. Explain the function of the grid-leak resistors, and state the reason why two resistors of the same value are used. Point out the r-f by-pass for these resistors.
6. State the purpose of the meter resistor.
7. Describe the transmission-line-type tank coil in the plate circuit.
8. Point out and describe the plate tuning capacitor.
9. Describe the coupling to the power amplifier.
10. State the value of plate voltage and trace its path to the plate of the tube.
11. State the functions of the r-f chokes. Point out the plate by-pass capacitor.
12. Briefly describe the need for neutralization and state the type used. Point out the neutralizing capacitor and describe its action. Point out the neutralizing link and state its purpose.
13. Explain the need for filament bias and point out the bias circuit.
14. State the function of resistor 189-5.
15. Point out the locations of the test points on the equipment and in the schematic diagram, and explain their use.

CONCLUSIONS

Abnormal operation of either the oscillator, multiplier, or i-p-a circuits may be determined by the use of one key test point. Trouble may be quickly isolated to the i-p-a circuits by the use of one secondary test point.

ORAL QUIZ

1. What type of vacuum tube is used in the i.p.a.?
2. In what frequency range is the i.p.a. excited?
3. Why is it necessary to neutralize the amplifier?
4. What type of coupling is provided to the power amplifier?
5. Why are two grid-leak resistors of the same value used?

EXPERIMENT No. 5

SUBJECT

TIME ALLOTTED: 1½ HR.

Tuning and trouble shooting the intermediate power amplifier.

OBJECTIVE

To become familiar with the tuning and the method of trouble shooting the i.p.a.

EQUIPMENT REQUIRED

One (or more) BC-640-A or BC-640-B Radio Transmitter.

For each transmitter:
One suitable antenna (or dummy).
One d-c voltmeter, 500-volt and 1000-volt ranges.
One a-c voltmeter, 10-volt range.
One ohmmeter.

INSTRUCTIONS

Make sure that the proper input power is available to the cabinet terminal board. Operate POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H.V. switch. Adjust VOLTAGE INCREASE wheel for proper indication on OUTPUT VOLTAGE meter. Set TUNE-OPERATE switch to OPERATE. Open rear door of cabinet and remove neutralizing link from rear of oscillator panel. Set LOCAL-REMOTE switch to LOCAL.

Note: Before proceeding with step 1, check tuning of crystal oscillator and frequency-multiplier circuits.

PROCEDURE

1. Operate METER RANGE MILLIAMPERES switch to IPA-G, and note reading on M.A. CURRENT meter on amplifier panel. (For Radio Transmitter BC-640-A, take grid-current reading on GRID CURRENT meter, and cathode-current reading on CATHODE CURRENT meter. Both of these meters are located on the oscillator panel.) Meter should indicate more than 7 ma. If indication is less than 7 ma., repeat tuning procedure of crystal-oscillator and frequency-multiplier circuits.

2. Vary IPA dial for indication of minimum current. Note IPA dial reading. Minimum i-p-a grid current indicates that the i-p-a plate tank circuit is tuned to resonance.

3. Tune NEUTRALIZING dial for minimum deflection of meter pointer. Rotate IPA dial through setting noted in step 2. Set NEUTRALIZING dial at the point where minimum meter deflection is observed when the IPA dial is moved through resonance. This setting provides the correct external capacitance for neutralizing the i-p-a grid-plate interelectrode capacitance.

4. Set IPA dial to point noted in step 2. Tune D dial for maximum meter indication.

Note: This step must be repeated each time transmitter is neutralized.

5. Rotate IPA dial through resonance for minimum meter indication. IPA stage is neutralized if dip of meter is small or if no dip is observed. If indication is otherwise, repeat step 3 and 4. If dip is small or no dip is observed, set IPA dial to point noted in step 2.

6. Set TUNE-OPERATE switch to TUNE. Open rear door of cabinet and replace oscillator-panel neutralizing link. Retune D dial for maximum meter indication.

7. Tune IPA dial for maximum meter indication. Set CO-T1-T2-D-IPA to IPA. Set METER RANGE MILLIAMPERES switch to EXC-C. Vary IPA dial for minimum meter indication.

Note: Maximum grid current and minimum cathode current should occur simultaneously; if not, readjust NEUTRALIZING dial slightly. Large adjustments will require reneutralizing.

8. Set TUNE-OPERATE switch to OPERATE, and set METER RANGE MILLIAMPERES switch to IPA-G. Rotate IPA dial for maximum meter indication.

9. Test Point E : Set METER RANGE MILLIAMPERES switch to EXC-C, and CO-T1-T2-D-IPA switch to IPA. The M.A. CURRENT meter should read 50 to 70 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.) Set METER RANGE MILLIAMPERES switch to IPA-G. M.A. CURRENT meter should read more than 7 ma. (For Radio Transmitter BC-640-A, take this reading on GRID CURRENT meter on oscillator panel.) These two readings provide an indication of the over-all operation of the crystal oscillator, frequency-multiplier circuits, and intermediate power amplifier. A check of test point E5 , which is the same as the first check at test point E , will isolate trouble to the intermediate power amplifier.

10. Operate LOCAL-REMOTE switch to REMOTE and POWER MAINS switch to OFF. Open rear door of equipment and remove interpanel wiring harness from rear of oscillator panel. Remove the eight mounting screws from front of panel, and lift panel from rack. Support it at rear of cabinet and reattach wiring to terminal strip. Extend wiring as necessary by attaching the required length of wire between terminal stud and soldering lug on wiring harness. Tape joints as necessary.

11. Connect d-c voltmeter, 1000-volt range, between terminal 17 on rear of chassis and ground. Set POWER MAINS switch to ON, and LOCAL-REMOTE switch to LOCAL. Depress interlock switch. WARNING: HIGH VOLTAGE IS PRESENT IN THE OSCILLATOR PANEL AND THROUGHOUT THE EQUIPMENT. The meter should indicate 780 to 850 volts. A reading of this value shows that the proper plate voltage is being supplied to the i-p-a tube. Set POWER MAINS switch to OFF, and disconnect meter leads.

12. Set POWER MAINS switch to ON. Make the necessary voltage measurements to complete CHART A. Make all measurements from the tube-socket pins to ground.

CHART A

PIN NO.	VOLTAGE	CIRCUIT
Plate cap (top)		
Grid cap (side)		
1		
4		

13. Operate POWER MAINS switch to OFF, and remove wiring harness from terminal-strip assembly. Loosen setscrews and remove plate and grid caps from i-p-a tube. Push down on both high sides of spring ring, and lift tube from socket. Using an ohmmeter, make the necessary resistance measurements to complete CHART B. Make all measurements from the tube-socket pins to ground unless otherwise stated.

CHART B

PIN NO.	RESISTANCE	CIRCUIT
Plate lead		
Grid lead		
1		
4		
Between 1 and 4		

14. Replace i-p-a tube.

Note: In replacing grid and plate leads of VT204, tighten setscrews only enough to secure the cap in position. Reset oscillator panel in rack, and replace wiring harness.

15. The instructor will simulate trouble in the intermediate power amplifier circuits. Locate the defect by using the procedure outlined in this experiment.

CONCLUSIONS

1. If the oscillator panel is removed from the rack, supported at the rear of the cabinet, and the wiring harness reattached, what factor will prevent the final amplifier from oscillating?

2. If an infinite resistance is measured between pins 1 and 4 of the tube socket, with the tube out of the socket, what is the probable cause of trouble?

3. If a low or zero resistance is measured from the plate lead to ground, what component is probably defective?

4. If a 5000-ohm resistance is measured from the grid lead to ground, what is the probable cause of trouble?

5. If a high d-c potential is measured between grid and ground, what component is the probable cause of trouble?

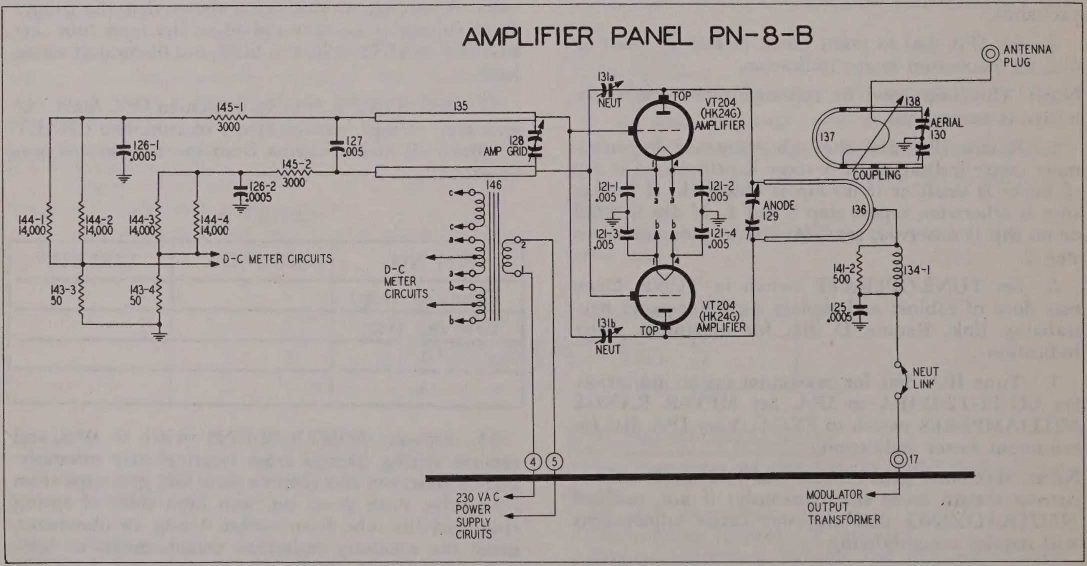
LECTURE No. 7

ANALYSIS OF POWER-AMPLIFIER AND OUTPUT CIRCUITS

The power amplifier is the final radio-frequency amplifying stage. It delivers approximately 50 watts of carrier power to the output circuits when it is driven by the intermediate power amplifier. No frequency multiplication is accomplished in this stage; it is excited at the transmission frequency throughout the frequency range of the transmitter.

Two VT204 tubes, commercial type HK24G, are operated in push-pull, with a transmission-line grid inductance and a transmission-line type plate inductance.

The power-amplifier and output circuits are shown in block form in figure 18 and Wall Chart No. 1, and in schematic form in figure 24.


AMPLIFIER PANEL PN-8-B
145-1
3000
135
126-1
.0005
127
.005
128
AMP GRID
145-2
3000
126-2
.0005
146
144-1
14,000
144-2
14,000
144-3
14,000
144-4
14,000
D-C METER CIRCUITS
D-C
METER
CIRCUITS
143-3
50
143-4
50
c
c
a
a
b
b
2
1
4
5
230 VAC
POWER
SUPPLY
CIRUITS
131a
NEUT
TOP
VT204
(HK24G)
AMPLIFIER
121-1
.005
121-2
.005
121-3
.005
121-4
.005
a
a
b
b
ANODE
129
131b
NEUT
TOP
VT204
(HK24G)
AMPLIFIER
ANTENNA
PLUG
138
AERIAL
130
137
COUPLING
136
141-2
500
134-1
125
.0005
NEUT
LINK
17
MODULATOR
OUTPUT
TRANSFORMER

TP-9689

Figure 24. Power-Amplifier and Output Circuits

POWER-AMPLIFIER CIRCUITS

The power-amplifier circuits are physically located on Amplifier Panel PN-8-B. When this panel is in the cabinet, the transmission-line-type grid inductance is partially in parallel with the plate transmission-line-type tank coil of the intermediate power amplifier. Thus the two stages are inductively coupled. The coupling is not very critical, but in order to prevent any stray interaction, a metal shield, with a hole cut in it to allow only the necessary coupling, is provided on the bottom of the amplifier panel.

Grid inductor 135 consists of two 7-inch sections of ¼-inch (outside diameter) silver-plated copper tubing, bent to form an "L". The amount of inductance included in the grid circuit is determined by the relative physical position of the grid shunt capacitor, 127. This capacitor is used so that individual grid-current readings may be taken, since it will pass r-f, but not the rectified grid current. It is physically mounted on the grid inductor, and held in position by four screws. The position of the capacitor may be varied after loosening these screws.

The dual variable capacitor, 128, is used for tuning the grid circuit. This component is physically mounted close to the grid connections of the tubes, and its rotor is ungrounded. It is mechanically coupled through an insulated bushing to the AMP. GRID dial on the front of the amplifier panel.

When excitation is applied to this stage, grid bias for the two tubes is developed by six resistors. Resistors 145-1, 144-1, and 144-2 develop operating bias for one tube; and resistors 145-2, 144-3, and 144-4, for the other tube. The grid-leak-bias resistors, 145-1 and 145-2, function as r-f chokes. Resistors 144-1 and 144-2 and resistors 144-3 and 144-4 are connected in parallel, within their respective grid circuits, because one resistor alone will not dissipate the required power to maintain the 2-watt standard throughout the equipment. Resistors 143-3 and 143-4 are used in their respective circuits to complete the circuit to ground when the d-c meter circuits are disconnected.

The filaments are by-passed to ground for radio frequency by capacitors 121-1 through 121-4, and are heated by a 6.3-volt potential derived from a secondary winding of transformer 146.

The plate inductance consists of two 15-inch sections of ¼-inch (outside diameter) silver-plated copper tubing, bent to form an "L". The use of this transmission-line-type inductor provides high efficiency and a more stable circuit. A plate-line shorting bar is shunted across the plate inductor. In order to tune the plate circuit from 100 to 156 mc., the length of the tuned line must be changed so that the band is divided into two sections. For 100 to 125 mc., the shorting bar is used in the vertical portion of the tuned line; for 125 mc. in the vertical portion just below the bend; and for 126 to 156 mc., in the horizontal portion of the line.

A special type dual capacitor, 129, functions as the plate tuning capacitor. It is mechanically coupled by an eccentric-cam arrangement to the ANODE control dial on the front panel. This cam is shaped in such a manner that variations of the dial will cause the capacitance to vary in approximately a straight-line frequency curve. The plate circuit is at resonance when this capacitor is tuned to the point where minimum cathode current is indicated. The range of the plate tuning capacitor is spread over almost the entire ANODE dial for each setting of the tuning bar.

The 800-volt d-c plate voltage is fed from terminal 17, on the rear of the chassis, through the neutralizing link and r-f choke coil 134-1, to the center tap of the plate tank coil. This voltage is reduced to one-half when the TUNE-OPERATE switch is set at the TUNE position. The r-f choke prevents radio-frequency energy from being fed back to the modulator plate circuit. The cold side of this choke is by-passed to ground by capacitor 125. Resistor 141-2 functions as a parasitic suppressor.

Since triode tubes are used in the amplifier circuit, the circuit must be neutralized. Conventional push-pull or cross neutralization is used. Variable capacitor 131 functions as the neutralizing capacitor. The two sections of this capacitor are mechanically coupled together with an insulated bushing, and are mechanically coupled through another insulated bushing and shaft, to the NEUT. dial on the front of the panel.

OUTPUT CIRCUITS

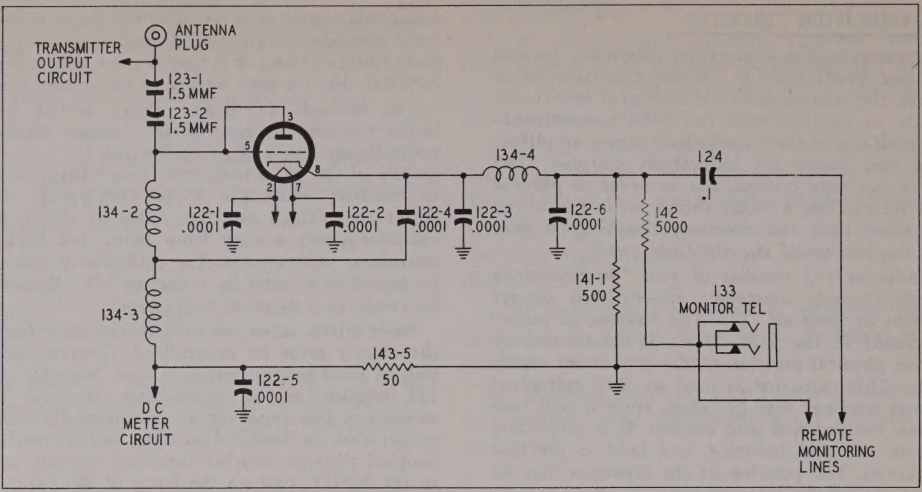
A transmission-line-type link is used to couple the power amplifier to the antenna plug. This link, 137, consists of two 7-inch pieces of silver-plated copper tubing, ¼-inch outside diameter, spaced 1⅛ inches apart, and bent to form a "U". It is tuned with a dual capacitor, 130, with the rotor grounded. The capacitor is mechanically coupled to AERIAL dial on the front of the panel.

The antenna inductor (137, 138) is mounted with a pin hinge, and is mechanically coupled, through a cam arrangement, to the COUPLING control on the front panel. By varying this control, the relative position of the antenna inductor, with respect to the plate inductor, may be changed. Thus, the degree of coupling between the two circuits is variable. Coupling to the antenna plug is made with a loop of 1/16-inch copper tubing, which is both inductively and directly coupled to the antenna inductor (137, 138). This additional coupling loop is used to improve the impedance match between the transmitter output and the transmission line, so that a more consistent output is provided over the entire frequency range.

MONITOR-RECTIFIER CIRCUITS

A diode rectifier stage, employing tube VT94 (commercial type 6J5), is used to demodulate a small amount of the radio-frequency carrier and provide an audio signal, which is used to check the voice output of the transmitter and to provide an indication of overmodulation. The rectified current may be checked by connecting meter 139 into the circuit; the audio output may be checked locally by plugging a headset into a jack or, remotely, by connecting appropriate remoting lines to the equipment. These circuits are shown in figure 25.

The grid and plate of the triode tube are tied together and are connected through two low-loss mica capacitors (123-1 and 123-2 in series) to the antenna terminal. Using these two capacitors in series gives a high voltage breakdown rating and yet allows sufficient r-f energy to be fed to the grid and plate terminals. Since the amount of capacitance used is small,



TP-9682

Figure 25. Monitor-Rectifier Circuits

this circuit has but little effect upon the antenna circuit.

Three identical radio-frequency choke coils (134-2, -3, -4,) are used to prevent any r-f signal from reaching the monitor output terminals. Capacitors 122-4, 122-5, and 122-6 are used to by-pass stray r-f signals to ground.

The cathode of the tube is connected to ground through r-f choke 134-4 and the monitor load resistor 141-1. The output of the rectifier is fed to jack 133 and to terminal 10 on the rear of the chassis. Capacitor 124 is used to block direct current and allow only audio signals to pass. If resistor 142 were not used and no plug were in jack 133, the monitor load resistor 141-1 would be short-circuited to ground through the jack. To prevent this short circuit so that the signal may be monitored at a remote point, resistor 142 is inserted in series with the output.

TEST POINTS

The M.A. CURRENT meter, when connected to indicate the monitor-rectifier grid current, is a major test point for the r-f circuits of the transmitter, and is designated test point ②. A normal grid-current reading indicates that the r-f circuits are operating normally. The same meter is also designated key test point Ⓕ, which is used to isolate trouble to the power-amplifier and output circuits.

LESSON PLAN No. 7

TIME ALLOTTED: 1½ HR.

SUBJECT

Power-amplifier and output circuits.

OBJECTIVE

To analyze the power-amplifier and output circuits.

INTRODUCTION

The power amplifier is the final radio-frequency amplifier stage. It delivers approximately 50 watts of carrier power to the output circuits when it is driven by the intermediate power amplifier. No frequency multiplication is accomplished in this stage; it is excited at the transmission frequency throughout the frequency range of the transmitter.

SUBJECT MATERIAL

1. Display Wall Chart No. 1, and briefly review the action of the power-amplifier and output circuits.

2. Display Wall Chart No. 2, and point out the power-amplifier and output circuits.

3. State the circuit and the type vacuum tubes used in the power-amplifier stage.

4. Draw the input circuits on the blackboard, as shown in figure 24. Discuss coupling to the input circuit and describe the transmission-line-type grid inductance. State the functions of the grid resistors, by-pass capacitors, and the grid-inductance capacitor. Give the reason why a capacitor is used for grid shorting.

5. State the reason for the filament capacitors and name the source of the filament voltage.

6. Explain the plate circuit and describe the plate inductor.

7. Describe the position of the plate-line shorting bar for operation from 100 to 125 mc.; for 126 to 156 mc.

8. Show the path of the high voltage from the terminal stud to the plates of the tubes.

9. Explain the function of the r-f choke, parasitic resistor, and by-pass capacitor.

10. Explain why neutralization is required and de-

scribe the neutralization circuit. Point out the neutralization link.

11. Explain the operation of the output circuits. Describe the various components contained in the output circuits.

12. Describe the monitor rectifier circuits and state their functions.

13. Point out the test points in the schematic and on the equipment, and explain their uses.

CONCLUSIONS

The monitor rectifier is used to check the operation of the power-amplifier and output circuits.

ORAL QUIZ

1. What type vacuum tube is used in the power amplifier?

2. What is the value of the plate voltage when the TUNE-OPERATE switch is set to the TUNE position?

3. Why are two identical grid-leak resistors used in parallel?

4. Why is the additional coupling loop used to match the transmitter output to the transmission line?

5. What are the advantages of the transmission-line-type inductor in the plate circuit?

EXPERIMENT No. 6

TIME ALLOTTED: 3 HR.

SUBJECT

Tuning, adjustment, and trouble-shooting procedures for the power-amplifier and output circuits.

OBJECTIVE

To become familiar with the tuning, adjustment, and trouble-shooting procedures for the power-amplifier and output circuits.

EQUIPMENT REQUIRED

One (or more) Radio Transmitter BC-640-A or BC-640-B.

For each transmitter:
One suitable antenna (or dummy).
One d-c voltmeter, 1000-volt range.
One a-c voltmeter, 10-volt range.
One 8.3, 6.9, and 5.5-mc. crystal units.

INSTRUCTIONS

Make certain that the proper input power is available at the cabinet terminal board. Push PRESS OFF buttons of MASTER FILAMENTS and MASTER H.V. switches. Make certain that neutralizing link, on rear of amplifier panel, is out.

PROCEDURE

1. Note frequency of crystal in crystal socket. Open rear door of equipment and examine position of plate-line shorting bar. If the transmitter output frequency is 125 mc. or less, the shorting bar should be in the vertical portion of the tuned line. If the transmitter output frequency is 126 mc. or more, the shorting bar should be in the horizontal portion of the tuned line. To move or adjust shorting bar, loosen setscrews with thumbs, and move shorting bar to a position where it is ¼-inch from the fillister screw heads in either the horizontal or vertical portion of the tuned line. Tighten setscrews. Close rear door of equipment.

2. Set POWER MAINS switch to ON. Push PRESS ON buttons of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H.V. switch. Adjust VOLTAGE INCREASE wheel for proper indication on OUTPUT VOLTAGE meter. Set LOCAL-REMOTE switch to LOCAL, and TUNE-OPERATE switch to OPERATE. Set C1-C2 switch to C1, and G1-G2-MON. switch to G1. Set METER RANGE MILLIAMPERES switch to PA-G. Tune AMP. GRID dial for maximum meter indication. (For Radio Transmitter BC-640-A, take this reading on the GRID CURRENT meter.) The meter should read more than 8 ma.

3. Tune ANODE dial for minimum indication of meter pointer. Note the ANODE dial setting, which is the setting required to resonate the power-amplifier plate-tank circuit.

4. Tune NEUT. dial for minimum deflection of meter pointer. Rotate ANODE dial through setting found in step 3. The final setting of the NEUT. dial is that which gives the smallest meter deflection when the ANODE dial is tuned through resonance. At this setting the correct external capacitance is provided to neutralize the grid-plate interelectrode capacitance.

5. Reset ANODE dial to resonance setting of step 3. Retune AMP. GRID dial for maximum deflection of meter pointer. Rotate ANODE dial through resonance to obtain minimum deflection of meter pointer. The amplifier is neutralized if the grid-current dip is small, or if no dip is observed. If a large dip is obtained, repeat steps 4 and 5. Note: Step 5 must be repeated each time the transmitter is neutralized.

6. Push PRESS OFF button of MASTER H.V. switch, and set POWER MAINS switch to OFF. Replace amplifier neutralizing link at rear of panel. Operate POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS. Wait one minute and then push PRESS ON button of MASTER H.V. switch. Operate TUNE-OPERATE switch to TUNE.

7. Set METER RANGE MILLIAMPERES switch to PA-G, and C1-C2 switch to C1. Retune ANODE dial for minimum indication of cathode current. Note reading observed on meter. Operate METER RANGE MILLIAMPERES switch to PA-G, and note reading.

8. Set C1-C2 switch to C2, and METER RANGE

MILLIAMPERES switch to PA-C, and note reading. Reading observed should be within 3 ma. of first reading in step 7. Set METER RANGE MILLIAMPERES switch to PA-G, and note reading. Reading observed should be within 3 ma. of second reading step 7. If meter readings vary more than 3 ma., amplifier tubes VT204 are unbalanced and should be replaced.

10. Set C1-C2 switch to C1, and METER RANGE MILLIAMPERES switch to PA-C. Retune ANODE dial for minimum meter indication. Set G1-G2-MON. switch to G2, and METER RANGE MILLIAMPERES switch to PA-G. Retune ANODE dial for maximum meter indication. Minimum cathode current and maximum amplifier grid current should occur simultaneously. If not, readjust NEUT. dial slightly. Large readjustments will require reneutralizing. Be sure to remove the neutralizing link when neutralizing.

11. Set TUNE-OPERATE switch to OPERATE, and remove crystal from socket. Set METER RANGE MILLIAMPERES switch to PA-G. Set G1-G2-MON. switch to G1 and then G2. Meter indication should be zero for both positions of G1-G2-MON. switch, if not, rotate NEUT. dial counterclockwise until meter reads zero. Repeat step 10. Replace crystal and set COUPLING dial to 70. Note: If NEUT. dial is moved more than 5 dial divisions, reneutralize the amplifier.

12. Set C1-C2 switch to C1, and METER RANGE MILLIAMPERES switch to PA-C. Retune ANODE dial for minimum indication on meter. IMPORTANT: KEEP CATHODE CURRENT UNDER 75 MA.

13. Tune AERIAL dial for maximum meter indication. Tune coupling dial for approximately 75 ma. Check dial readings with tuning chart. The transmitter should be loaded until the total cathode current for both output tubes minus the total grid current for both amplifier tubes equals 120 ma. Retune ANODE dial for minimum meter indication, and then readjust COUPLING dial.

Note: If the 5.5, 6.9, and 8.3 mc., (or similar) crystals are not available, disregard steps 14 through 17.

14. Plug 5.5-mc. crystal into crystal socket. Place plate-line shorting bar approximately ¼ inch from stop on vertical portion of plate line. Operate POWER MAINS switch to ON, and tune transmitter to 100 mc. When transmitter is properly tuned for 100 mc., the ANODE dial should read between 2 and 5; if not, readjust plate-line shorting bar. To increase dial reading, move bar down; to decrease, move bar up. CAUTION: Always turn off all power before adjusting shorting bar.

15. Plug 6.9 mc. crystal into crystal socket. Place plate-line shorting bar approximately ¼ inch from stop on horizontal portion of plate line. Set POWER MAINS switch to ON, and tune transmitter to 125 mc. When the transmitter is properly tuned, the ANODE dial should read approximately zero.

16. Plug 8.3-mc. crystal into crystal socket. Place plate-line shorting bar approximately ¼ inch from stop on horizontal portion of plate line. Set POWER MAINS switch to ON, and tune transmitter for 150 mc. When the transmitter is properly tuned, the ANODE dial should read between 95 and 97. To increase dial reading, move bar away from vacuum tubes; to decrease, move bar toward vacuum tubes.

17. Test points ⬠2 and ●F : Set G1-G2-MON. switch to MON., and METER RANGE MILLIAMPERES switch to PA-G. The M.A. CURRENT meter should read more than 1 ma. (For Radio Transmitter BC-640-A, take this reading on GRID CURRENT meter.) For this check the meter is a major test point that indicates the over-all operation of the r-f circuits. The meter is also used as a key test point to check the operation of the power-amplifier and output circuits.

18. Set POWER MAINS switch to OFF. Open rear door of cabinet, and connect d-c voltmeter, 1000-volt range, between terminals 17 and 14 on rear of amplifier panel (positive lead to terminal 17). Set POWER MAINS switch to ON, depress interlock switch, and set LOCAL-REMOTE switch to LOCAL. Meter should indicate 780 to 850 volts, showing that the proper voltage is being fed from the power supply, through the secondary winding of the modulator output transformer. Operate POWER MAINS switch to OFF, and disconnect meter leads.

19. Set COUPLING dial to 100, to lower antenna coupling loop. Remove wiring harness from rear of amplifier panel. Remove the eight mounting screws from front of panel, and lift panel from rack. Support it at rear of cabinet, and reattach wiring harness. Extending wiring as necessary, and tape all joints. Set POWER MAINS switch to ON. CAUTION: HIGH VOLTAGES ARE PRESENT ON THE AMPLIFIER PANEL AND THROUGHOUT THE EQUIPMENT. Make the necessary voltage measurements to complete CHART A. Make all measurements from the tube cap leads or socket pins to ground.

CHART A
FRONT TUBE

PIN NO.	VOLTAGE	CIRCUIT
Plate cap (top)		
Grid cap (side)		
1		
4		
REAR TUBE		
Plate cap (top)		
Grid cap (side)		
1		
4		

20. Operate POWER MAINS switch to OFF, and remove wiring harness from terminal-strip assembly. Loosen setscrews, and remove plate and grid caps from amplifier tubes. Push down on both high sides of spring ring, and lift tube from socket. Using an ohmmeter, make the necessary resistance measurements to complete CHART B. Make all measurements from the tube-socket pins to ground unless otherwise stated.

CHART B

FRONT TUBE

PIN NO. 8	RESISTANCE	CIRCUIT
Plate lead		
Grid lead		
1		
4		
Between 1 and 4		
REAR TUBE		
Plate lead		
Grid lead		
1		
4		
Between 1 and 4		

21. The instructor will simulate trouble in the power-amplifier circuits. Locate the defect by referring to the procedure outlined in this experiment.

CONCLUSIONS

1. If an ohmmeter, connected between the plate cap of the front amplifier tube and ground, indicates approximately 10,050 ohms, what component is probably defective?

2. If a 3000-ohm indication is obtained from each grid circuit to ground, what component is probably defective?

3. If the plate by-pass capacitor were shorted, what would be the approximate voltage from terminal 17 to ground?

4. In what portion of the plate line is the shorting bar adjusted for operation in the 100-to-125-mc. band?

5. If all meter readings for the amplifier panel are abnormally low, what is the most logical check to make before checking out the various supply circuits?

REVIEW No. 1

Display Wall Charts No. 1 and No. 2, and review the important points contained in Lectures No. 1 through No. 7 and Experiments No. 1 through No. 6, by orally interrogating the students. The normal time allotment for this review is three hours.

Beginning with Lesson Plan No. 1, state each question contained in the Oral Quiz of each Lesson Plan, and each question contained in the Conclusions of each Experiment, in turn. Fully explain the answers to all questions which cause the students difficulty. Permit the students to ask questions of their own, and allow classroom discussion on questions, within reasonable limits of time. Make a written note of each question that causes the students general difficulty.

◀ EXAMINATION No. 1 ◀

Examination No. 1 covers the material contained in Lectures No. 1 through No. 7 and Experiments No. 1 through No. 6. The normal time allotment for this examination is two hours.

Do not permit the students to refer to any material while answering the questions in Part I of the examination. Display Wall Charts No. 1 and No. 2 before presenting Part II of the examination.

Part I

1. What is the maximum possible coverage from an aircraft station at 10,000 feet to a ground station in level country, in the very-high-frequency range?

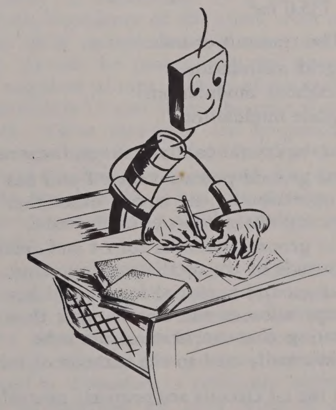
2. What is the frequency range of Radio Transmitter BC-640-B?

3. What general factors limit the coverage in v-h-f operation?

4. Using the official nomenclature list the eight major physical units contained in Radio Transmitter BC-640-B.

5. What is the function of the autotransformer located at the bottom of the cabinet?

6. What is the function of the power-control circuits?



7. What circuits are supplied by the lower power-supply panel? What circuits are supplied by the upper power-supply panel?

8. What type of modulator circuit is used in the equipment?

9. What is the main advantage of the crystal-oscillator circuit as compared to other types of oscillators?

10. Name the class of operation used in the frequency-multiplier circuits?

11. Radio Transmitter BC-640B is capable of emitting:

a. frequency-modulated voice transmission and 1000-cycle modulated-continuous-wave telegraphy (MCW), with a nominal output of approximately 50 watts.
b. amplitude-modulated voice transmission and continuous-wave telegraphy (CW), with a nominal output of approximately 500 watts.
c. frequency-modulated voice transmission and continuous-wave telegraphy (CW), with a nominal output of approximately 500 watts.
d. amplitude-modulated voice transmission and 1000-cycle modulated-continuous-wave telegraphy (MCW), with a nominal output of approximately 50 watts.

12. When set at TUNE, the TUNE-OPERATE switch on the control panel halves:

a. the filament-supply voltage to the oscillator and amplifier panels, thereby halving the output voltages of these panels.
b. the filament-supply voltage to the modulator and amplifier panels, thereby halving the output voltages of these panels.
c. the plate-supply voltage to the tubes in the modulator and amplifier panels.
d. the plate-supply voltages to the tubes in the oscillator and amplifier panels.

13. If the crystal frequency is 7.5 mc., the output of the 2nd-tripler stage is:

a. 22.5 mc.
b. 45.0 mc.
c. 67.5 mc.
d. 135.0 mc.

14. The transmitter uses:

a. grid modulation.
b. cathode modulation.
c. plate modulation.

15. In the crystal-oscillator stage, the screen grid is:

a. at ground potential for r-f and has no part in the operation of the circuit other than to set the operating characteristics of the tube.
b. at ground potential for r-f and determines the magnitude of the oscillating frequency.
c. at ground potential for a-f and has no part in the operation of the circuit other than to set the operating characteristics of the tube.
d. internally tied to the cathode of tube VT66.

16. If the r-f circuits are properly neutralized, what is the effect on grid current in the power amplifier when the crystal is removed from the socket? The transmitter is in the keyed state.

a. no effect.
b. current drops to zero.
c. current rises excessively.
d. current drops to a very low value.

17. The oscillator panel contains the:

a. crystal-oscillator, 1st-tripler, 2nd-tripler, doubler, and power-amplifier circuits.
b. crystal-oscillator, 1st-tripler, 2nd-tripler, and power-control circuits.
c. crystal-oscillator, 1st-tripler, 2nd-tripler, doubler, and intermediate-power-amplifier circuits.
d. crystal-oscillator, 1st-tripler, 2nd-tripler, driver, and intermediate-power-amplifier circuits.

18. Coupling to the power amplifier is:

a. direct.
b. inductive.
c. capacitive.
d. direct and inductive.

19. The crystal oscillator is a:

a. tuned-plate, crystal-controlled oscillator and functions as a frequency-generating device only.
b. tuned-plate, tuned-grid, crystal-controlled oscillator and functions as a frequency-generating device only.
c. tuned-plate, crystal-controlled oscillator and functions as a second-harmonic generator.
d. tuned-plate, tuned-grid, crystal-controlled oscillator and functions as a second-harmonic generator.

20. The desired crystal frequency may be readily determined by:

a. a frequency meter.
b. a neon lamp.
c. dividing the output frequency of the transmitter by 18.
d. multiplying the output frequency of the transmitter by 18.

Part II

1. What is the d-c potential on the screen of the 1st tripler when the TUNE-OPERATE switch is in the TUNE position and the transmitter is in an unkeyed state?

a. 150 volts.
b. 75 volts.
c. zero.

2. If capacitor 165 is open, an abnormal indication will be obtained at test point:

a. E1.
b. E2.
c. G.

3. If all d-c meter indications are one-half the normal value, what is the probable cause of trouble?

4. The transmitter is tuned and keyed. When the crystal is removed from the socket, the grid-current reading falls to a low value. What is the probable cause of trouble?

a. Defective crystal.
b. Defective lower power-supply panel.
c. Unbalanced amplifier tubes.
d. Improper neutralization.

5. When the CO/T1 dial is rotated, the crystal-oscillator cathode current remains constant. What is the probable cause of trouble?

a. Defective capacitor 163-1.
b. Open cathode circuit.
c. Defective capacitor 175.

6. If the indication is abnormally low at test point 1 and zero at test point 2, what is the logical functional block to check first?

a. Power-supply circuits.
b. Radio-frequency circuits.
c. Audio-frequency circuits.

7. The indication is normal at test point 1, but no voltage is present at the plate cap of the intermediate-power-amplifier tube. The transmitter is in the keyed state. What is the probable cause of trouble?

a. Open interpanel wiring.
b. Shorted capacitor 168-3.
c. Open resistor 158.
d. Shorted neutralizing link.

8. No cathode current is indicated in either of the power-amplifier tubes. What is the probable cause of trouble?

a. Open capacitor 121-2.
b. Open resistor 141-2.
c. NEUT. LINK not in place.
d. Shorted capacitor 130.

9. If capacitor 161-4 is shorted, what is the effect on the indication at test point E1 ?

a. None.
b. Abnormally low indication.
c. Fluctuating indication.

10. The oscillator panel is removed from the rack, and the wiring harness is removed from the rear of the chassis. An ohmmeter is connected between the plate of the 2nd tripler and ground. An indication of 15000 ohms is observed. What is the probable trouble?

a. Shorted capacitor 166-3.
b. Shorted capacitor 166-2.
c. Open coil 182.

REVIEW OF EXAMINATION No. 1

Display Wall Charts No. 1 and No. 2 and review, orally, the questions on Examination No. 1. The normal time allotment for this review is one hour.

State each question contained in Examination No. 1, in turn. Fully explain the answers to all questions which cause the students difficulty. Permit the students to ask questions of their own. Allow classroom discussion on questions, within reasonable limits of time. Make a written note of each question that causes the students general difficulty.

LECTURE No. 8

ANALYSIS OF AUDIO-AMPLIFIER AND MODULATOR CIRCUITS

The audio-amplifier circuits are used to amplify the voice signal at normal input levels, or a 1000-cycle tone signal to drive the modulator. Inputs are provided for either local or remote operation. The modulator is a zero-bias class-B amplifier, which provides 100 per cent high-level plate modulation for the power amplifier. These circuits are physically located on Modulator Panel PN-10-B, and are shown, in block form, in figure 18 and Wall Chart No. 1 and, in schematic form, in figure 26.

For local operation, single-button Microphone T-48-A may be plugged into MICROPHONE NO. 1 jack, 41, or single-button British microphone BT-23 may be plugged into MICROPHONE NO. 2 jack, 42. These jacks are connected in series and, to eliminate any stray r-f pick-up, they are by-passed by capacitors 31-1, 31-2, 31-3, and 31-4.

Terminals 13 and 14 on the rear of the chassis are connected to terminals 36 and 37 on the cabinet terminal board. See Wall Chart No. 2. For remote operation, the remote-line input is connected through these terminals to the LOCAL-REMOTE switch, 55. This control is a one-way lever key, which has six sets of make-and-break contacts of the anticapacitance type. The input terminals 13 and 14 are by-passed for stray radio-frequency signals by capacitors 31-7 and 31-8.

The primary of transformer 56 is in two sections, having a total impedance of 600 ohms, with center-tap leads from each section brought out to individual terminals. 24-volt d-c power from the power-supply circuits is supplied to taps 3 and 4 of the transformer, through terminals 15 and 16 on the rear of the modulator panel. These terminals are by-passed for r-f signals by capacitors 31-6 and 31-5. Taps 3 and 4 of the primary winding are by-passed for speech frequencies by capacitor 37. Thus, the primary winding of the transformer acts as a single winding for pulsating currents.

Two resistors, 45-1 and 45-2, are connected in series with the lever key and the center tap leads 2 and 5. These resistors are used to attenuate the local speech input. The remote-speech input is connected across the total impedance of the primary winding at terminals 1 and 6. Therefore, a relatively uniform input level will be obtained for both types of operation, since the remote input will be attenuated by the remoting lines. All leads from the primary winding of the transformer are by-passed for radio frequencies by capacitors 31-24 through 31-29. Figure 27A shows a simplified schematic diagram of the local input circuit; figure 27B shows a simplified diagram of the remote input circuit.

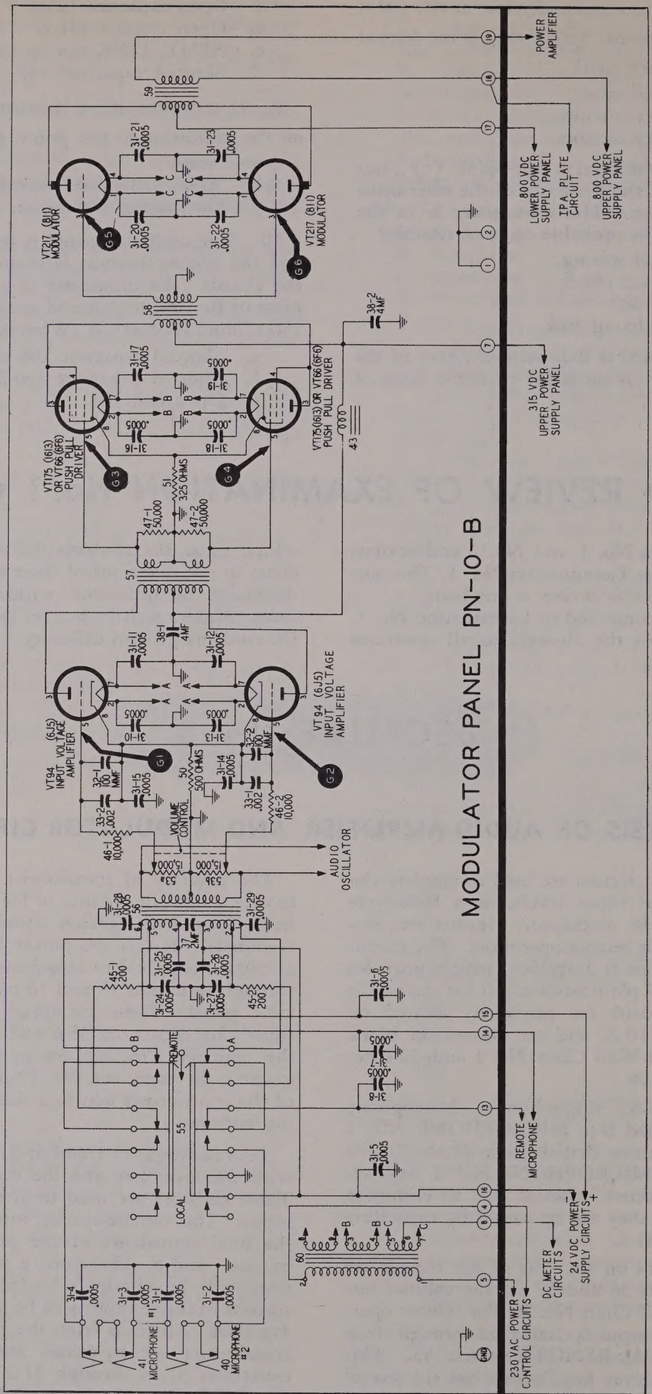

MODULATOR PANEL PN-10-B
VT217 (811) MODULATOR
VT217 (811) MODULATOR
VT175 (1613) OR VT66 (6F6) PUSH PULL DRIVER
VT175 (1613) OR VT66 (6F6) PUSH PULL DRIVER
VT94 (6J5) INPUT VOLTAGE AMPLIFIER
VT94 (6J5) INPUT VOLTAGE AMPLIFIER
G1
G2
G3
G4
G5
G6
POWER AMPLIFIER
800 VDC LOWER POWER SUPPLY PANEL
IPA PLATE CIRCUIT
800 VDC UPPER POWER SUPPLY PANEL
315 VDC UPPER POWER SUPPLY PANEL
230 VAC POWER CONTROL CIRCUITS
DC METER CIRCUITS
24 VDC POWER SUPPLY CIRCUITS
REMOTE MICROPHONE
AUDIO OSCILLATOR
VOLUME CONTROL
LOCAL
REMOTE
55
41 MICROPHONE #1
40 MICROPHONE #2
31-4 .0005
31-3 .0005
31-1 .0005
31-2 .0005
60
45-1 200
45-2 200
31-24 .0005
31-25 .0005
37 2MF
31-26 .0005
31-27 .0005
56
31-28 .0005
31-29 .0005
53a 15,000
53b 15,000
46-1 10,000
33-2 .002
32-1 100 MMF
31-15 .0005
50 500 OHMS
31-14 .0005
33-1 .002
46-2 10,000
32-2 100 MMF
31-10 .0005
31-13 .0005
31-11 .0005
31-12 .0005
38-1 4MF
57
47-1 50,000
47-2 50,000
51 325 OHMS
31-16 .0005
31-18 .0005
31-17 .0005
31-19 .0005
43
58
38-2 4MF
31-20 .0005
31-21 .0005
31-22 .0005
31-23 .0005
59
31-5 .0005
31-6 .0005
31-7 .0005
31-8 .0005
A
B
C
GND
1
2
3
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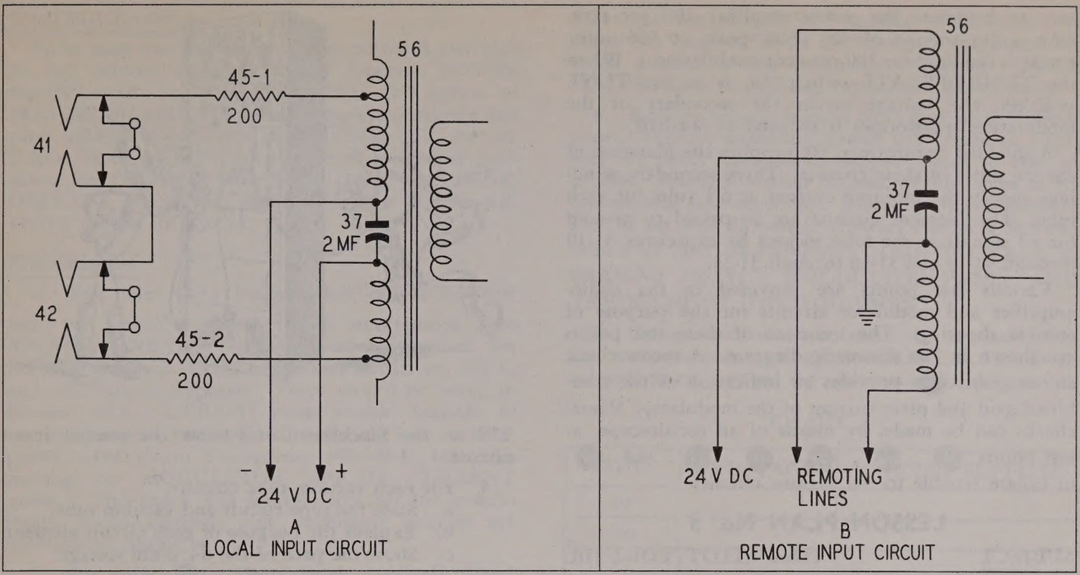
Figure 26. Audio-Amplifier and Modulator Circuits



A
LOCAL INPUT CIRCUIT

B
REMOTE INPUT CIRCUIT

TP-9683

Figure 27. Simplified Diagram of Local and Remote Input Circuits

The speech amplifier is the first audio-amplifier stage. It operates as a push-pull class-A voltage amplifier, which amplifies the input sufficiently to drive the push-pull driver stage. A pair of VT94 (commercial type 6J5) high-mu metal-type triode tubes are used.

Transformer 56 couples the audio input signal to the grid circuits of the speech amplifier. The transformer provides a voltage gain in the grid circuit, and matches the low-impedance input circuit to the high-impedance grid circuit. The secondary winding of the microphone transformer has a total impedance of 30,000 ohms. Shunted across this winding is a two-section potentiometer, 53, the tap of which is mechanically coupled to the VOLUME CONTROL on the front of the panel. This control is a slotted screwdriver-type adjustment; clockwise rotation moves the tap away from ground potential, thereby providing an increase in resistance.

The parallel combination of resistor 46-1 and capacitor 33-2 functions as a grid-circuit audio filter for one tube; resistor 46-2 and capacitor 33-1, for the other tube. These components filter the high-frequency audio coupled from the input circuits. Capacitors 32-1 and 32-2 by-pass any stray radio frequencies.

The cathodes of the two tubes are connected together, and are connected to ground through the cathode bias resistor, 50. Since approximately 8 volts of cathode bias is developed across this resistance, the plates are kept within the rated dissipation and damage to the tube is avoided when the grid voltage is zero. Capacitors 31-14 and 31-15 function as cathode by-pass capacitors in their respective circuits.

315-volt d-c plate voltage is fed from terminal 7 on the rear of the chassis, through a-f choke 43, to the center tap on the primary winding of coupling transformer 57. This choke provides additional filtering for the plate supply, and drops the value of the plate voltage to 240 volts. It also prevents any interaction between the stages. Capacitor 38-1 is the plate-circuit by-pass.

The output of the speech amplifier stage is coupled to the input of the driver stage by transformer 57. The driver operates as a power amplifier, to drive the modulator. Two VT175 (commercial type 1613) vacuum tubes or two VT66 (commercial type 6F6) vacuum tubes are used in push-pull. Since low plate-load-resistance tubes are desirable for driving the class-B modulator, each tube is used as a triode, with the plate and screen grid connected together.

Resistors 47-1 and 47-2 are used as grid load resistors in their respective circuits. The cathodes of the two tubes are tied together, and bias is developed across the common cathode-bias resistor, 51.

315-volt d-c plate voltage is fed from terminal 7 on the rear of the chassis to the center tap on the primary winding of the interstage transformer, 58. The plate circuit is by-passed to ground by capacitor 38-2.

The modulator uses two VT217 tubes (commercial type 811) in push-pull. These tubes are operated as zero-bias class-B amplifiers. This type of circuit is used since high-level plate modulation requires maximum power output with minimum distortion.

Since the tubes operate within the rated dissipation at zero grid bias, the center tap of the coupling transformer, 58, is grounded. 800-volt d-c plate voltage is fed from the upper power-supply panel, through terminal 17, to the center tap of the coupling transformer. A potential of 850 volts, d.c., is supplied to terminal 18 by the lower power-supply panel. Terminal 19 is the modulation output terminal, and has a d-c potential of 800 volts, plus the audio voltage necessary to modulate the power amplifier 100 per cent. (An audio voltage of 800 volts, peak, or 566 volts, r.m.s., is required for 100 per cent modulation.) When the TUNE-OPERATE switch, 14, is at the TUNE position, the voltage across the secondary of the modulation transformer is reduced to one-half.

A shielded transformer, 60, supplies the filaments of the six tubes in these circuits. Three secondary windings supply the required current at 6.3 volts for each tube. The filament circuits are by-passed to ground for r-f signals at the tube sockets by capacitors 31-10 through 31-13 and 31-16 through 31-23.

Various test points are provided in the audio-amplifier and modulator circuits for the purpose of trouble shooting. The locations of these test points are shown in the schematic diagram. A meter check at test point (G) provides an indication of the combined grid and plate current of the modulator. Visual checks can be made, by means of an oscilloscope, at test points (G1), (G2), (G3), (G4), (G5), and (G6) to isolate trouble to the various circuits.

LESSON PLAN No. 8

SUBJECT TIME ALLOTTED: 1 HR.

Audio-amplifier and modulator circuits.

OBJECTIVE

To analyze the audio-amplifier and modulator circuits.

INTRODUCTION

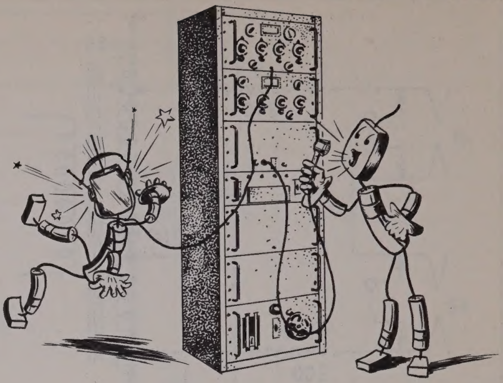
The audio-amplifier circuits are used to amplify voice signals, at normal input levels, or a 1000-cycle tone signal to drive the modulator. Inputs are provided for either local or remote operation. The modulator is a zero-bias class-B amplifier, which provides 100-per cent high-level plate modulation for the power amplifier.

SUBJECT MATERIAL

1. Display Wall Chart No. 1, and briefly review the action of the audio-amplier and modulator circuits.

2. Display Wall Chart No. 2, and point out the audio-amplifier and modulator circuits.

3. Describe the input circuits and state the function of each component. Draw figure 27A on the blackboard and show the local input circuit. Draw figure 27B on the blackboard and show the remote input circuit.



4. For each vacuum-tube circuit:
   a. State the type circuit and vacuum tube.
   b. Explain the purpose of each circuit element.
   c. Show the path of the d-c plate voltage.

5. Name the test points used in trouble shooting the audio and modulator circuits, and point out their locations on the equipment.

CONCLUSIONS

A zero-bias class-B modulator is used since high-level plate modulation requires maximum power output with minimum distortion. One key test point and six secondary test points aid in trouble shooting the audio and modulator circuits.

ORAL QUIZ

1. Does the type input used affect the amplitude of the audio signal reaching the driver stage?

2. What value of the plate voltage is supplied to the speech-amplifier and driver stages when the TUNE-OPERATE switch is set at TUNE?

3. Why is a class-B modulator used with high-level plate modulation?

4. In what direction must the VOLUME CONTROL be turned to increase the amplitude of the input signal to the grid circuit of the speech amplifier?

EXPERIMENT No. 7

SUBJECT TIME ALLOTTED: 2½ HR.

Trouble shooting the audio-amplifier and modulator circuits.

OBJECTIVE

To become familiar with the method of trouble shooting the audio-amplifier and modulator circuits.

EQUIPMENT REQUIRED

One (or more) Radio Transmitter BC-640-A or BC-640-B.

For each transmitter:

One d-c voltmeter with 500 and 1000-volt ranges.

One a-c voltmeter with 10-volt range.

One ohmmeter.

One oscilloscope.

One headset.

One microphone.

INSTRUCTIONS

Make sure that the proper input power is available to the cabinet terminal board. Operate POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and push PRESS ON button of MASTER H.V. switch. Adjust VOLTAGE INCREASE wheel for proper indication on OUTPUT VOLTAGE meter. Set TUNE-OPERATE switch to OPERATE and LOCAL-REMOTE switch to LOCAL.

PROCEDURE

1. Test point 3 : Plug headset into MONITOR jack on amplifier panel. Plug microphone into MICROPHONE NO. 1 jack on modulator panel. Set METER RANGE MILLIAMPERES switch to MOD., and talk into microphone. Voice should be heard in headset; M.A. CURRENT meter should indicate 40 ma. at no signal, and approximately 108 ma. on voice peaks. (For Radio Transmitter BC-640-A, take this reading on MODULATOR ANODE CURRENT meter.) This check will indicate whether the speech-input, audio-amplifier, and modulator circuits are functioning normally.

2. Test point G : Short-circuit terminals 11 and 12 on rear of modulator panel. Turn volume control 52, on rear of chassis, fully clockwise. M.A. CURRENT meter on amplifier panel should indicate approximately 110 ma. (For Radio Transmitter BC-640-A, take this reading on MODULATOR ANODE CURRENT meter on modulator panel.) This test will check the operation of the audio-amplifier, modulator, and audio-oscillator circuits, but not the speech-input circuits.

3. Test points G1 and G2 : Operate POWER MAINS switch to OFF. Open rear door of cabinet and remove speech-amplifier tubes. Connect oscilloscope between pin 5 of tube socket and ground. Operate POWER MAINS switch to ON and depress interlock switch. A 1000-cycle undistorted sine-wave pattern should be observed on oscilloscope. Make this test at both sockets. This check will serve to isolate trouble to the grid circuits of the speech-amplifier and the audio-oscillator circuits. Operate POWER MAINS switch to OFF. Disconnect test leads and replace speech-amplifier tubes.

4. Test points G3 and G4 : Remove driver tubes. Connect oscilloscope between pin 5 of tube socket and ground. Operate POWER MAINS switch to ON. The sine-wave pattern presented on the screen should be identical in shape to the one observed in step 3; however, the pattern should be approximately 16 times larger. Make this test at both tube sockets. These tests may be used to isolate trouble to the output circuits of the speech amplifier and the input circuits of the driver stage. Operate POWER MAINS switch to OFF. Disconnect test leads and replace driver tubes.

5. Test points G5 and G6 : Remove modulator tubes. Connect oscilloscope between pin 3 of socket and ground. Operate POWER MAINS switch to ON. The oscilloscope pattern should be identical in shape to that in step 4, but approximately four times larger. Make this test at both tube sockets. These tests will check the output circuits of the driver stage and the input circuits of the modulator. Operate POWER MAINS switch to OFF and replace modulator tubes.

6. Remove wiring harness from rear of modulator panel. Remove mounting screws from front of panel and lift panel from rack. Support panel at rear of cabinet. Reattach wiring harness, extend wires as required, and tape all joints. Short-circuit terminals 11 and 12 on rear of panel. Operate POWER MAINS switch to ON. WARNING: HIGH VOLTAGE IS PRESENT IN THE MODULATOR PANEL AND THROUGHOUT THE EQUIPMENT.

7. Using a d-c voltmeter, make the necessary voltage measurements to complete CHART A. Make all measurements between the terminal studs and ground.

CHART A

STUD	VOLTAGE	CIRCUIT SUPPLIED
19		
18		
17		
7		
15		

8. Make the necessary voltage measurements to complete CHART B. Make all measurements between socket pins and ground. Use an a-c voltmeter for the filament circuits.

CHART B

SPEECH-AMPLIFIER TUBES

PIN NO.	VOLTAGE		CIRCUIT
	LEFT TUBE	RIGHT TUBE	
3			
5			
8			
2			
7			
DRIVER TUBES			
3			
4			
5			
8			
2			
7			
MODULATOR TUBES			
Plate cap			
3			
1			
4			

9. Operate POWER MAINS switch to OFF. Remove wiring harness from rear of panel. Turn volume controls 52 and 53 fully clockwise. Remove tubes from sockets and make the necessary resistance measurements to complete CHART C. Make all measurements between tube-socket pins and ground, unless otherwise indicated.

10. The instructor will simulate trouble in the equipment. Use the procedure in this experiment to locate the defective component.

CONCLUSIONS

1. A normal indication is observed at test point G1, but an abnormal indication is observed at test point G2. What circuit is probably defective?

2. When an ohmmeter is connected between the plates of the speech amplifier and ground, a reading of approximately 50,000 ohms is observed. What component is probably defective?

3. If a normal indication is observed at test points G3 and G4, but an abnormal indication is observed at test points G5 and G6, what circuit is probably defective?

4. Plate voltage is present at terminal 7 on the rear of the chassis, but no voltage is present at the tubes. What is the probable cause of trouble?

5. When an ohmmeter is connected between the cathode circuit of the driver stage and ground, an infinite resistance reading is observed. What component is probably defective?

CHART C
SPEECH-AMPLIFIER TUBES

PIN NO.	RESISTANCE		CIRCUIT
	LEFT TUBE	RIGHT TUBE	
3			
5			
8			
7 Between 2 and 7			
DRIVER TUBES			
3			
4			
5			
8			
7			
Between 2 and 7			
MODULATOR TUBES			
Plate lead			
3			
4			
Between 1 and 4			

LECTURE No. 9

ANALYSIS OF AUDIO-OSCILLATOR CIRCUIT

The audio oscillator functions as a 1000-cycle tone source when the transmitter is used for m-c-w operation. Its output is injected into the input of the speech amplifier. Thereafter the signal is amplified and used to modulate the carrier in the same manner as the speech input. The oscillator circuit, which is shown in block form in figure 18 and in schematic form in figure 28, is physically located on the modulator panel. A triode tube VT94 (commercial type 6J5) is used as a simple series-fed Hartley-type audio oscillator.

Transformer 61 has two windings; the turns ratio of primary to secondary is 10 to 1. 250 volts, d.c., is fed from choke 43 to the center tap of the primary. Resistor 49 functions as the plate series resistance, and the value of this resistance determines the magnitude of oscillations. The frequency is determined by the oscillator tank capacitor, 35, which has a low temperature coefficient. Capacitor 34, which functions as the grid blocking capacitor, isolates the plate supply from the grid and allows the grid to develop its own bias across the grid-leak resistor, 48.

The output of the oscillator is fed from the secondary winding of the transformer, and is shunted with a dual-section potentiometer, 52, which functions as the audio-oscillator volume control. The two taps of this unit are mechanically ganged and coupled to a control on the top of the chassis. See figure 10. This control has a screwdriver slot for adjustment; clockwise rotation moves the tap away from ground potential, thereby providing an increase in resistance.

The oscillator functions at all times and the output is fed from the two taps of the volume control to the secondary terminals of the microphone input transformer, through keying relay 42. This relay, which is a quick-acting type capable of making 12 pulses per second, operates on the 6-volt direct current provided by selenium half-wave rectifier 54. The input voltage to this rectifier is obtained from the filament supply of the tube. The keying relay is energized when terminals 11 and 12 on the rear of the chassis are shorted or when a telegraph key is connected to these terminals and the contacts closed.

The filaments are heated by a 6.3-volt potential supplied by a secondary winding of filament transformer 60. Capacitors 36-1 and 36-2 function as the filter capacitors for the rectifier output. Any stray radio-frequency energy is by-passed to ground by capacitor 31-9.

Test points G1 and G2 may be used to check the output of the oscillator, or an aural check may be made by plugging a headset into the MONITOR jack on the amplifier panel.

LESSON PLAN No. 9

SUBJECT TIME ALLOTTED: ¼ HR.

Audio-oscillator circuit.

OBJECTIVE

To analyze the audio-oscillator circuit.

INTRODUCTION

The audio oscillator functions as 1000-cycle tone source when the transmitter is used for m-c-w operation. Its output is injected into the input of the speech amplifier. Thereafter the signal is amplified and used to modulate the carrier in the same manner as the speech input.

SUBJECT MATERIAL

1. Display Wall Chart No. 1, and briefly review the action of the audio oscillator.

2. Display Wall Chart No. 2, and point out the audio-oscillator circuits.

3. State the type circuit and vacuum tube.

4. State the function of each component.

5. Trace the output of the oscillator to the speech amplifier.

6. Describe the keying relay and the 6-volt rectifier circuit from which its power is obtained.

7. Point out the test points which may be used to check the operation of the oscillator.

CONCLUSIONS

The output of the audio oscillator, which functions at all times during normal transmitter operation, is controlled by the keying relay. Abnormal operation of the audio oscillator may be detected by the use of an oscilloscope or by means of an aural check.

ORAL QUIZ

1. What is the purpose of the audio oscillator?

2. The value of what component determines the frequency?

3. From what source does the keying relay obtain its power?

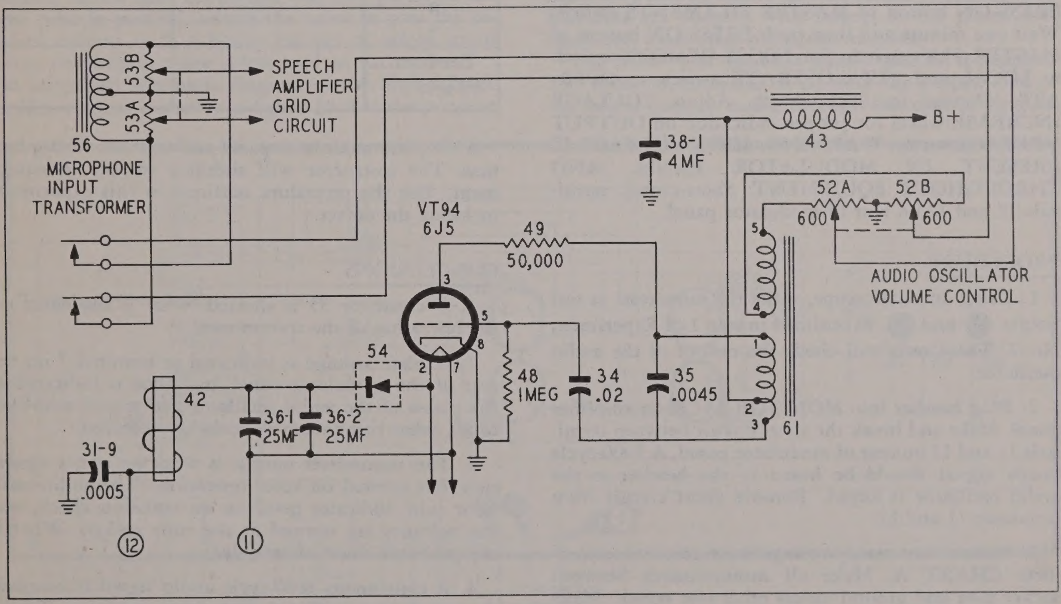

53B
53A
56
MICROPHONE
INPUT
TRANSFORMER
SPEECH
AMPLIFIER
GRID
CIRCUIT
B+
43
38-1
4MF
52A
52B
600
600
AUDIO OSCILLATOR
VOLUME CONTROL
VT94
6J5
49
50,000
3
5
8
2
7
54
42
36-1
25MF
36-2
25MF
48
1MEG
34
.02
35
.0045
5
4
1
2
3
61
31-9
.0005
12
11

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Figure 28. Audio-Oscillator Circuit

EXPERIMENT No. 8

TIME ALLOTTED: 1 HR.

SUBJECT

Trouble shooting the audio-oscillator circuit.

OBJECTIVE

To become familiar with the method of trouble shooting the audio-oscillator circuit.

EQUIPMENT REQUIRED

One (or more) Radio Transmitter BC-640-A or BC-640-B.
For each transmitter:
One d-c voltmeter with 10-volt and 500-volt ranges.
One a-c voltmeter with 10-volt range.
One oscilloscope.
One ohmmeter.
One headset.

INSTRUCTIONS

Remove wiring harness from rear of modulator panel. Remove panel from rack and support it at rear of cabinet. Reattach wiring harness, extend wiring as required, and tape all joints. Make certain that the proper input power is available at the cabinet terminal board. Operate POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H.V. switch. Set LOCAL-REMOTE switch to LOCAL and TUNE-OPERATE switch to OPERATE. Depress interlock switch. Adjust VOLTAGE INCREASE wheel for proper indication on OUTPUT VOLTAGE meter. WARNING: HIGH VOLTAGE IS PRESENT IN MODULATOR PANEL AND THROUGHOUT EQUIPMENT. Short-circuit terminals 11 and 12 on rear of modulator panel.

PROCEDURE

1. Using an oscilloscope, make the same tests at test points G1 and G2 as outlined in step 1 of Experiment No. 7. These tests will check the output of the audio oscillator.

2. Plug headset into MONITOR JACK on amplifier panel. Make and break the short circuit between terminals 11 and 12 on rear of modulator panel. A 1000-cycle m-c-w signal should be heard in the headset as the audio oscillator is keyed. Remove short circuit from terminals 11 and 12.

3. Make the necessary voltage measurements to complete CHART A. Make all measurements between socket pins and ground unless otherwise noted. Make filament check with a-c voltmeter.

4. Connect positive lead of d-c voltmeter, 10-volt range, to terminal 12 on rear of chassis. Connect negative lead to terminal 11. The voltmeter should indicate approximately 6 volts, indicating that the coil of relay 42 is being properly supplied.

5. Operate POWER MAINS switch to OFF. Remove wiring harness from rear of modulator panel. Remove audio-oscillator tube VT94. Make the necessary resistance checks to complete CHART B. Make all checks between socket pins and ground unless otherwise noted.

CHART A

PIN NO.	VOLTAGE	CIRCUIT
3		
5		
8		
Between 2 and 7		

CHART B

PIN NO.	RESISTANCE	CIRCUIT
3		
5		
8		
7		
Between 2 and 7		

6. Replace modulator panel and reattach wiring harness. The instructor will simulate trouble in equipment. Use the procedure outlined in this experiment to locate the defect.

CONCLUSIONS

1. If capacitor 35 is shorted, what is the effect on the operation of the transmitter?

2. If plate voltage is indicated at terminal 7 on the rear of the modulator panel, but none is indicated at the plates of the audio oscillator and speech amplifier tubes, what component is probably defective?

3. The transmitter output is weak on m-c-w operation, but normal on voice operation. The audio-oscillator tube indicates good on an emission check, and the voltages are normal at the tube socket. What is the probable cause of trouble?

4. A continuous 1000-cycle audio signal is heard in the transmitter output during voice operation. Terminals 11 and 12 on the rear of the modulator panel are neither internally nor externally shorted, and no keying device is connected to these terminals. What component is probably defective?

LECTURE No. 10

ANALYSIS OF POWER-SUPPLY CIRCUITS

The secondary power requirements of the equipment are met by the power-supply circuits. These circuits provide a high d-c voltage for the various plate and screen-grid circuits; a low d-c voltage for operating certain relays; a low a-c voltage for operating certain pilot lamps; and a 6.3-volt a-c voltage for the various filament circuits throughout the equipment. Two power-supply panels are used; since these panels are identical electrically, the analysis in this lecture will apply to either panel.

The power-supply circuits are shown in block form in figure 18, and in schematic form in figure 29. They are physically located on the upper and lower Power-Supply Panels PN-12-A and Control Panel PN-11-A.

Four VT145 (commercial type 5Z3) high-vacuum rectifier tubes are used in a dual-voltage-type circuit which effectively functions as a full-wave center-tap rectifier and as a full-wave bridge rectifier. By using the high-vacuum tubes instead of mercury-vapor tubes there is less danger of arc-back and faulty starting of the rectifier in certain climates. Two plates, one from each of the tubes inserted in sockets 99-1 and 99-2, are tied together and connected to one side of the secondary winding of the high-voltage transformer 98. The remaining plates in each of the tubes are similarly tied and connected to the other side of the winding. Thus one plate of one tube and one plate of another tube are in parallel. Connecting the plates in this manner, rather than connecting the two plates in the same tube in parallel, allows the tubes to pass the required current with a better margin of safety, since at any one instant there is less load on each tube.

A simplified schematic diagram of the high-voltage rectifier circuits is shown in figure 30. For the purpose of analysis, the tubes are designated by their socket numbers and certain components are omitted. When the 230-volt a-c voltage is applied to the primary winding of transformer 98, an a-c potential is induced in the secondary winding. During one-half of the a-c cycle the upper end of the secondary winding is made positive with respect to the lower end. During this period current can flow from the lower end of the secondary, through tube 99-4, the load, and one-half of tubes 99-1 and 99-2, to the upper end of the secondary. During the next half of the a-c cycle the lower end of the secondary becomes positive with respect to the upper end. Current then flows, through tube 99-3, the load, and the other half of tubes 99-1 and 99-2, to the lower end of the secondary winding. Thus, full-wave bridge rectification occurs, and a d-c voltage of approximately 850 volts is developed across the load.

In order to provide an independent voltage, from the same high-voltage transformer, whose value is one-half (or less) of the voltage across the entire secondary, a center tap is brought out from the secondary winding. Thus, when tubes 99-1 and 99-2 are conducting in the bridge circuit, a separate voltage is developed between the load and the center tap. The tap is negative with respect to the load, but it is approximately 425 volts positive with respect to ground. This action is similar to that occurring in a conventional center-tapped full-wave rectifier, where the tap is grounded. The two tubes 99-3 and 99-4 have no part in this function; their filaments are positive with respect to the plates and, therefore, these tubes are nonconductive.

The primary of filament transformer 97 is supplied 230 volts, 50/60 cycles, a. c., from the output load of the power-control panel, through the control circuits.

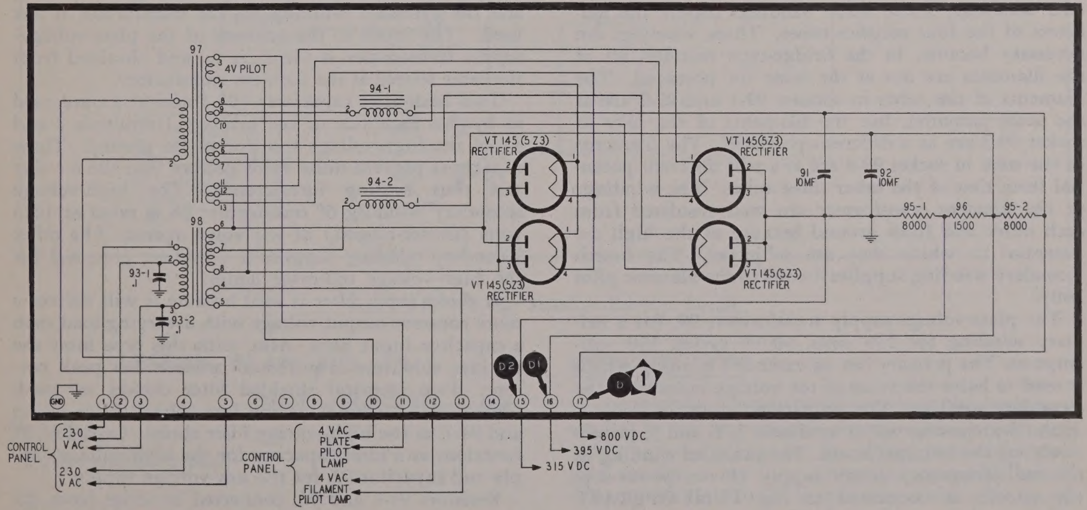

Figure 29. Power-Supply Circuits

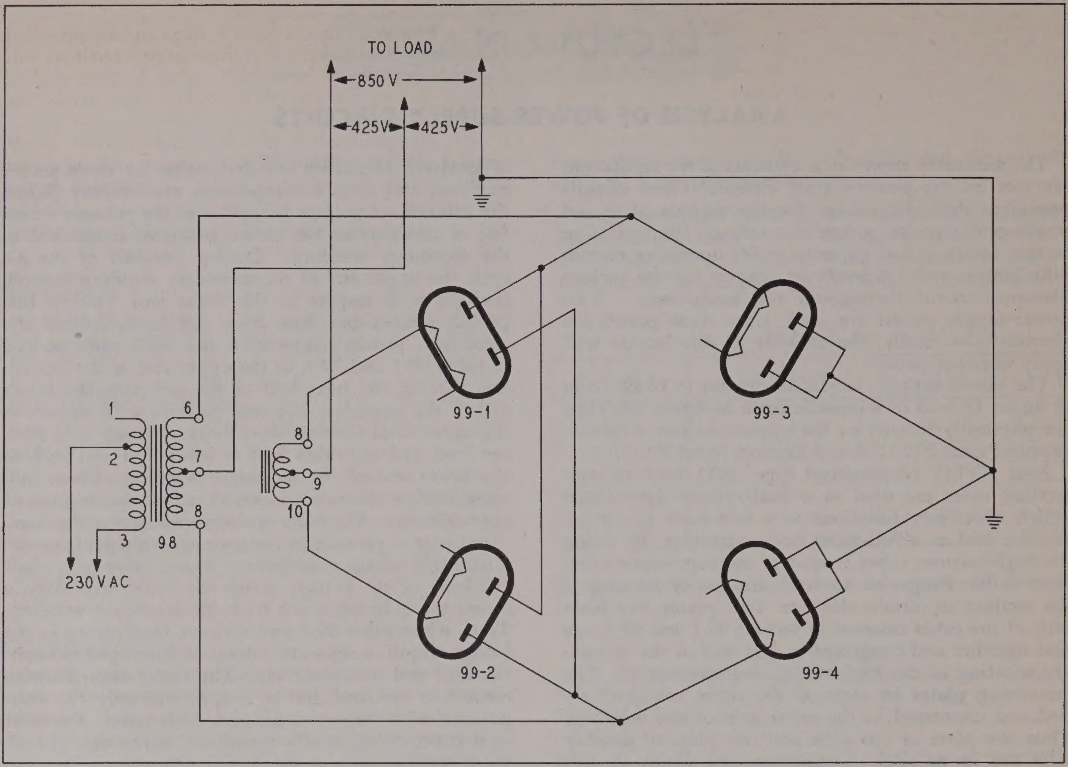

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Figure 30. Simplified Diagram of High-Voltage Rectifier Circuit

This transformer has four secondary windings, two of which are rated at 5 volts each at 15 volt-amperes and are center-tapped. The third winding has a rating of 30 volt-amperes but is otherwise identical to the first two windings. These three windings supply the filaments of the four rectifier tubes. Three windings are necessary because, in the bridge-type rectifier, all of the filaments are not at the same d-c potential. The filaments of the tubes in sockets 99-1 and 99-2 are at the same potential, but the filaments of the tube in socket 99-3 are at a different potential. The filaments of the tube in socket 99-4 are at a still different potential from that of the other three tubes. The windings of the filament transformer are well insulated from each other and from ground because of the high d-c potential to which they are subjected. The fourth secondary winding supplies 4 volts to the filament pilot lamp.

The plate-voltage-supply transformer, 98, has a primary winding for 230 volts, 50/60 cycles, 350 volt-amperes. The primary has an extended winding which is used to halve the value of the voltage induced in the secondary winding. The primary-winding terminals 1, 2, and 3 are connected to terminals 1, 2, and 3, respectively, on the terminal board. The extended winding in the radio-frequency power supply (lower power-supply panel) is connected to the TUNE-OPERATE switch on the control panel. This switch is used to reduce the maximum high voltage for the two radio-frequency panels to approximately one-half, as a protection when tuning the transmitter. The upper power-supply panel, which supplies the audio circuits, has no external connection to primary-winding terminal 1, and the extended winding on the transformer is not used. The input to the primary of the plate-voltage-supply transformer is identical to, and obtained from the same source as the filament transformer.

Two hash-filter capacitors (93-1 and 93-2) are used to by-pass each side of the primary (terminals 2 and 3) of the high-voltage transformer to ground. These capacitors prevent noise from getting into the a-c line and thus causing interference. The high-voltage secondary winding of transformer 98 is rated at 1025 volts (center-tapped) at 386 volt-amperes. The other secondary winding supplies a 4-volt a-c potential for the high-voltage indicator lamps.

A choke input filter is used because it will deliver a more constant output voltage with a varying load than a capacitor input filter. Also, with this type filter the rectifier tubes are required to conduct less peak current. Two identical shielded filter chokes are used. Choke 94-2 functions as the low-voltage filter choke and 94-1, as the high-voltage filter choke. Capacitor 91 functions as a filter capacitor for the high-voltage supply and capacitor 92, for the low-voltage supply.

Resistors 95-1 and 96, connected in series from the output of the low-voltage supply to ground, function as a bleeder and as a voltage divider. A lead connected from the junction of these two resistors to the terminal strip on the rear of the chassis supplies the voltage obtained by voltage division to certain circuits within the equipment. Resistor 95-2, connected across the direct current output of the two filter chokes, functions as the high-voltage bleeder. All three bleeder resistors are connected and held in position by fuse clips, similar to the cartridge-fuse type. Holes are punched in the top of the chassis to allow heat, dissipated by the bleeder resistors, to escape more freely.

The high-voltage, approximately 800 volts, is supplied to the equipment through terminal 17 on the rear of the chassis. The low voltage, approximately 395 volts, is supplied through terminal 16. This terminal is not externally connected on the upper power-supply panel since this unit supplies the audio circuits which do not require the 395 volts. The value of the voltage supplied to terminal 16 is dropped by the voltage divider 95-1 and 95-6 to approximately 330 volts, and is supplied to terminal 15. Terminal 14 is at ground potential.

A full-wave bridge-type selenium-rectifier circuit supplies a 24-volt d-c potential for operating certain relays on the control panel and the microphone circuits on the modulator panel. This circuit is physically located on Control Panel PN-11-A. Figure 31 shows the schematic diagram of the rectifier circuit.

The primary of rectifier transformer 16 is supplied 230 volts, a. c., which is derived from the output of the power control panel through the MASTER FILAMENTS switch. Terminals 3 and 4 on the secondary of the transformer supply 27 volts to the bridge circuit. A potential of 29 volts is available between terminals 3 and 5, and 31 volts between terminals 3 and 6. Although terminals 3 and 4 are normally used, higher voltage taps are provided since the internal resistance of the selenium rectifiers will increase with age and, hence, will require a higher applied voltage due to the increased voltage drop across the rectifier.

The selenium-rectifier circuit is conventional in all respects, and is capable of delivering a well-regulated power output. The negative output is grounded to the chassis. In the positive lead a capacitor-input-type filter is used to smooth the rectified output for the plate-control-relay supply. This filter consists of a single-section electrolytic input capacitor, 1-1, a filter choke, 9, in series with the positive lead, and another capacitor, 1-2, across the output of the supply. Resistor 11 functions as a bleeder and is connected directly across the output of the rectifier.

An additional filter circuit is used for the microphone input circuits. This filter consists of the coil on relay 8 and two capacitors, 1-3 and 1-4, across the output. The capacitors are connected into the circuit by the relay.

A voltage measurement at major test point 1 or key test point D, at terminal 17 of the power-supply panel, will check the operation of the power-supply circuits. Voltage measurements at secondary test points D1 and D2 may be used to further isolate trouble in the power-supply circuits. A voltage measurement at secondary test point C5 checks the output of the 24-volt selenium-rectifier circuit.

Filament voltage for the transmitter is obtained from individual filament transformers on the various panels. The primary of each transformer is supplied 230 volts, a. c., from the output of the power control panel, through various switches contained in the control circuits.

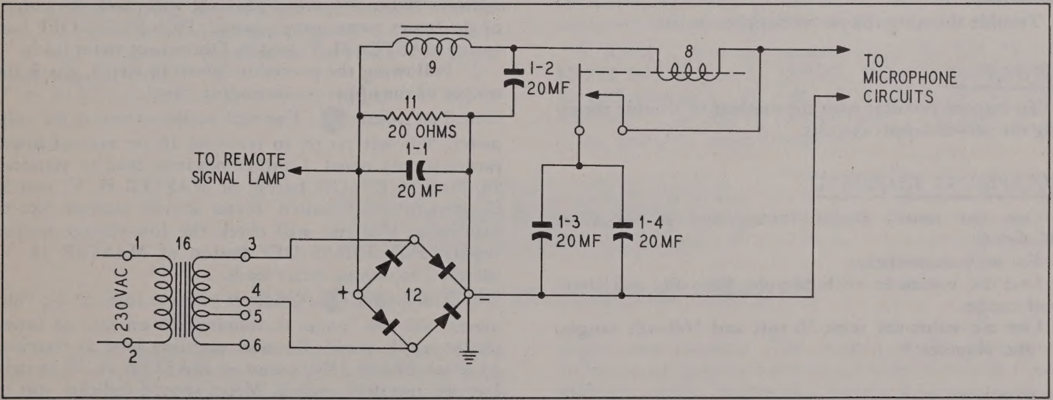

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Figure 31. 24-Volt Selenium-Rectifier Circuit

LESSON PLAN NO. 10

TIME ALLOTTED: 1 HR.

SUBJECT

Power-supply circuits.

OBJECTIVE

To analyze the power-supply circuits.

INTRODUCTION

The secondary power requirements of the equipment are met by the power-supply circuits. These circuits provide a high d-c voltage for the various plate and screen-grid circuits; a low d-c voltage for operating certain relays; a low a-c voltage for operating certain pilot lamps; and a 6.3-volt a-c voltage for the various filament circuits throughout the equipment.

SUBJECT MATERIAL

1. Display Wall Chart No. 1, and briefly review the action of the power-supply circuits.
2. Display Wall Chart No. 2, and point out the power-supply circuits on the schematic diagram.
3. State the type circuit and vacuum tubes used and explain their advantages.
4. Describe the interconnections of the tube plates.
5. Draw figure 30 on the blackboard, and describe the operation of the high-voltage rectifier circuits.
6. State the input voltage to the filament transformer. Describe the secondary windings and state their purpose.
7. State the input voltage to the high-voltage transformer. Describe the secondary windings and state their purpose.
8. State the function of the input filter capacitors.
9. Describe the filter circuits.
10. Point out the bleeder resistors and state their functions.
11. Show the external connections to the terminal strip, and state the value of voltage supplied to each terminal.
12. Point out the selenium-rectifier circuit on the control panel.
13. Describe the circuit and state the function of each component.
14. Point out the test points on the schematic diagram and on the equipment, and explain their use.
15. Point out the filament circuits on Wall Chart No. 2.

CONCLUSIONS

The power-supply circuits are checked by means of one major test point, one key test point, and three secondary test points.

ORAL QUIZ

1. Why are high-vacuum tubes used instead of mercury-vapor tubes?
2. What is the value of input voltage to the power-supply circuits?
3. Why are three different filament windings needed for the rectifier tubes?
4. If the TUNE-OPERATE switch were set to the TUNE position, would a normal indication be observed at test point 1 on the lower power-supply panel?
5. State the value of the rectified voltage supplied by the power-supply circuits.
6. What is the purpose of the selenium-rectifier circuit?

EXPERIMENT No. 9

TIME ALLOTTED: 2 HR.

SUBJECT

Trouble shooting the power-supply circuits.

OBJECTIVE

To become familiar with the method of trouble shooting the power-supply circuits.

EQUIPMENT REQUIRED

One (or more) Radio Transmitter BC-640-A or BC-640-B.

For each transmitter:

One d-c voltmeter with 50-volt, 500-volt, and 1000-volt ranges.

One a-c voltmeter with 10-volt and 500-volt ranges.

One ohmmeter.

INSTRUCTIONS

Make certain that the proper power input to the cabinet terminal board is available. Operate POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Set LOCAL-REMOTE switch to LOCAL, and TUNE-OPERATE switch to OPERATE.

PROCEDURE

1. Test point 1: Open rear door of cabinet. Connect positive lead of d-c voltmeter, 1000-volt range, to terminal 17 on rear of lower power-supply panel. Connect negative lead to terminal 14. Push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Adjust VOLTAGE INCREASE wheel for proper indication of OUTPUT VOLTAGE meter. The d-c voltmeter should indicate 780 to 850 volts. This test will check the output of the lower power-supply panel. Push PRESS OFF button of MASTER H. V. switch. Disconnect meter leads.
2. Following the procedure given in step 1, check the output of the upper power-supply panel.
3. Test point D1 : Connect positive lead of d-c voltmeter, 500-volt range, to terminal 16 on rear of lower power-supply panel. Connect negative lead to terminal 14. Push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Meter should indicate 380 to 410 volts. This test will check the low-voltage output supply. Push PRESS OFF button of MASTER H. V. switch. Disconnect meter leads.
4. Test point D2 : Connect positive lead of d-c voltmeter, 500-volt range, to terminal 15 on rear of lower power-supply panel. Connect negative lead to terminal 14. Push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Meter should indicate 300 to 330 volts. This test will check the dropping resistor on the low-voltage supply. Push PRESS OFF button of MASTER H. V. switch. Disconnect meter leads.
5. Following the procedure given in step 4, check the dropping resistor on the upper power-supply panel.
6. Test point C5 : Push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Connect d-c voltmeter, 50-volt range, between terminal 24, on rear of control panel, and ground. Meter should indicate 24 volts. This test will check the output of the selenium-rectifier circuit.
7. Operate POWER MAINS switch to OFF. Remove wiring harness from rear of lower power-supply panel. Remove panel from rack and support it at rear of cabinet.

Reattach wiring harness. Extend wiring as necessary and tape all joints. Operate POWER MAINS switch to ON. CAUTION: HIGH VOLTAGES ARE PRESENT ON POWER-SUPPLY PANEL AND THROUGHOUT EQUIPMENT.

8. Make the necessary a-c voltage measurements to complete CHART A.

CHART A

TERMINAL NO.	VOLTAGE	FUNCTION
1 and 3		
2 and 3		
4 and 5		
10 and 11		
12 and 13		

9. Push PRESS OFF button of MASTER H. V. switch. Using an a-c voltmeter, 10-volt range, measure the filament voltage between terminals 1 and 4 of each tube socket. The meter indication should be 5 volts, a. c., for each tube. CAUTION: DO NOT ATTEMPT TO MEASURE FILAMENT VOLTAGE WHILE PLATE VOLTAGE IS APPLIED TO RECTIFIER TUBES.

10. Operate POWER MAINS switch to OFF. Disconnect wiring harness from chassis. Using an ohmmeter, make the necessary measurements to complete CHART B. Make all measurements from the socket pins to ground.

11. Replace lower power-supply panel in rack. Reattach wiring harness. Remove wiring harness from rear of upper power-supply panel. Remove panel from rack and support it at rear of cabinet. Reattach wiring harness. Extend wiring as necessary and tape all joints. Operate POWER MAINS switch to ON. Repeat steps 8, 9, and 10 of this experiment to check the upper power-supply panel.

12. The instructor will simulate trouble in equipment. Use the procedure in this experiment to locate the defect.

CHART B

PIN NO.	SOCKET NO.	RESISTANCE	CIRCUIT
1	99-1		
1	99-2		
1	99-3		
1	99-4		
2	99-1		
3	99-1		
2	99-3		

CONCLUSIONS

1. Indicator lamp above R. F. H. V. switch on control panel is not lighted, but transmitter is operating normally otherwise. The pilot lamp is good. What is the probable cause of trouble?

2. A meter connected to test point 1 on lower power-supply panel indicates approximately 400 volts. What is the most logical check to make before proceeding with further voltage and resistance checks?

3. An infinite resistance indication is obtained between pin 1 of tube socket 99-4 and ground. The tube is in the socket and the filament circuit is complete within the tube. What is the probable cause of trouble?

4. 230 volts, a. c., is indicated between terminals 4 and 5 at rear of upper power-supply panel, but no filaments are lighted in chassis circuits or in audio circuits. What is the probable cause of trouble?

5. A low or zero-resistance indication is observed between the filaments of socket 99-1 and ground. What component is probably defective?

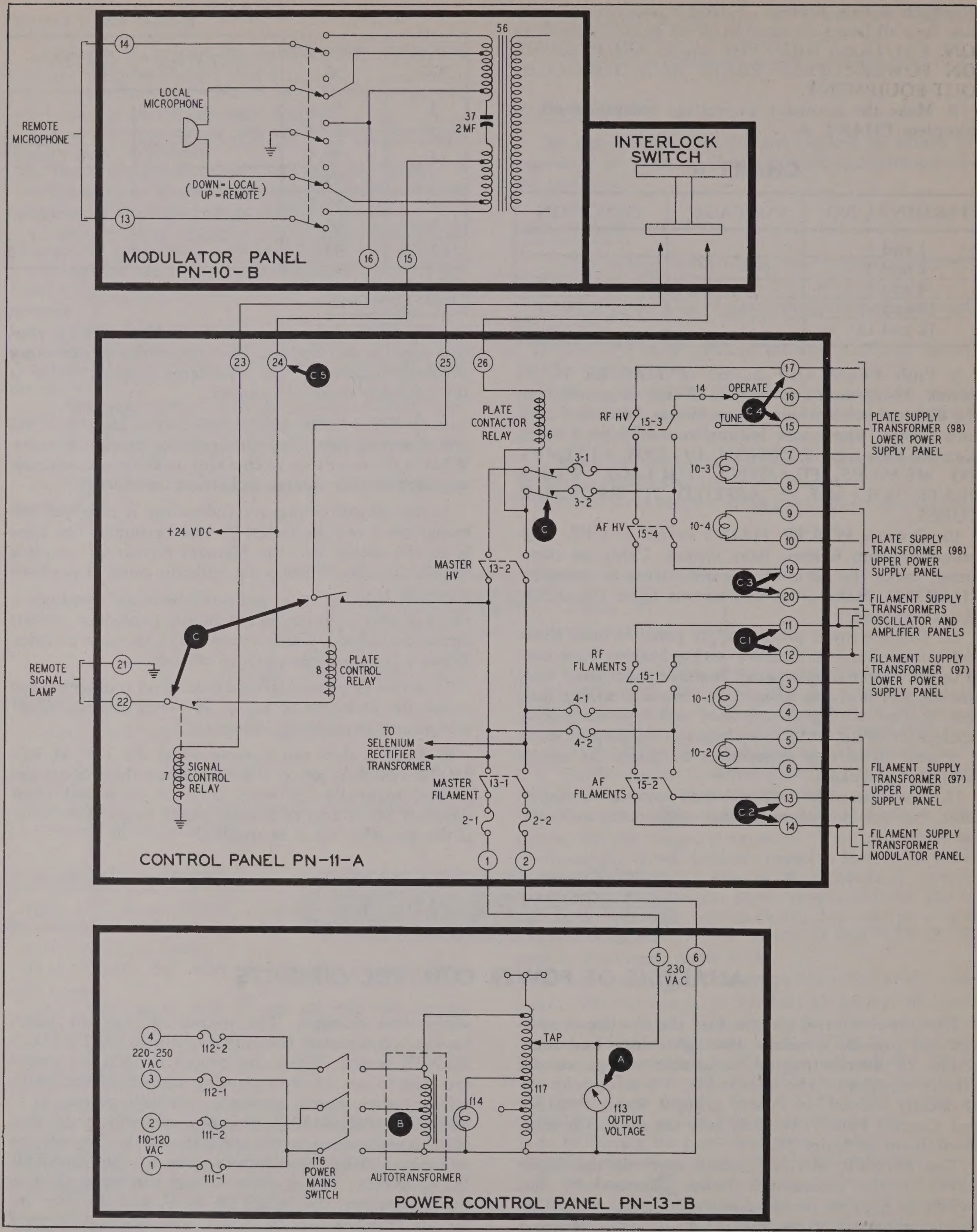
6. Relay 8 does not operate when the LOCAL-REMOTE switch is set to LOCAL. When the relay is depressed manually, 24 volts, d. c., is measured from terminal 24, on rear of control panel, to ground. What is the probable cause of trouble?

LECTURE No. 11

ANALYSIS OF POWER CONTROL CIRCUITS

The power control circuits fuse the line input voltage and provide a means, through switch and relay action, of distributing an adjustable voltage to the various circuits of the equipment. These circuits are physically located on Power Control Panel PN-13-B and Control Panel PN-11-A, and are shown in schematic form in figure 32.

The POWER MAINS switch controls the input power to the transmitter. Power admitted by this switch is applied to the autotransformer, which remains connected across the line at all times. When a 110-to-120-volt power source is applied to the input (one-half) of the autotransformer; the output load voltage at the end terminals is doubled. The variable-ratio line transformer 117, which is also connected across the line, can be used to either increase or decrease the voltage output to the load to compensate for supply-line changes. The output of the line transformer is completely controlled by the MASTER FILAMENTS switch. When this switch is open, no power can pass to any of the operating circuits of the transmitter; when closed, power is available to the A. F. and R. F. FILAMENT switches controlling the filament transformers, to the primary of the low-voltage selenium-rectifier transformer, and to the MASTER H. V. switch. Before plate voltage can be applied to the transmitter, the MASTER H. V. and the door interlock switches must be closed. Also, the plate control relay, 8, must be energized. This relay is energized by the 24-volt output of the selenium rectifier when the LOCAL-REMOTE switch is set at LOCAL, or when a microphone is connected across the remote microphone line (with the LOCAL-REMOTE switch set at REMOTE). Thus the comparatively small microphone


MODULATOR PANEL PN-10-B
REMOTE MICROPHONE
LOCAL MICROPHONE
(DOWN = LOCAL UP = REMOTE)
56
37 2 MF
14
13
16
15
INTERLOCK SWITCH
CONTROL PANEL PN-11-A
23
24
25
26
C5
PLATE CONTACTOR RELAY
6
RF HV
15-3
14
OPERATE
TUNE
C4
17
16
15
PLATE SUPPLY TRANSFORMER (98) LOWER POWER SUPPLY PANEL
3-1
3-2
10-3
7
8
C
AF HV
15-4
10-4
9
10
19
20
C3
PLATE SUPPLY TRANSFORMER (98) UPPER POWER SUPPLY PANEL
+24 VDC
MASTER HV
13-2
FILAMENT SUPPLY TRANSFORMERS OSCILLATOR AND AMPLIFIER PANELS
C
11
12
C1
RF FILAMENTS
15-1
PLATE CONTROL RELAY
8
FILAMENT SUPPLY TRANSFORMER (97) LOWER POWER SUPPLY PANEL
REMOTE SIGNAL LAMP
21
22
4-1
10-1
3
4
TO SELENIUM RECTIFIER TRANSFORMER
4-2
10-2
5
6
SIGNAL CONTROL RELAY
7
MASTER FILAMENT
13-1
AF FILAMENTS
15-2
13
14
C2
FILAMENT SUPPLY TRANSFORMER (97) UPPER POWER SUPPLY PANEL
2-1
2-2
FILAMENT SUPPLY TRANSFORMER MODULATOR PANEL
1
2
POWER CONTROL PANEL PN-13-B
5
6
230 VAC
TAP
4
220-250 VAC
112-2
3
112-1
2
111-2
110-120 VAC
1
111-1
116 POWER MAINS SWITCH
B
AUTOTRANSFORMER
114
117
A
113 OUTPUT VOLTAGE

TP9-121

Figure 32. Power Control Circuits

current energizes the plate-control relay, which closes and applies 230 volts, a. c., to plate-contactor relay 6. Relay 6 is large enough to control the heavy alternating current required by the transmitter. When the LOCAL-REMOTE switch is set at REMOTE, and the microphone is removed from the circuit, these two relays open and the carrier is cut off the air. A press-to-talk microphone, if available, can be used in either the local or remote operating positions. If one is used, the transmitter will be keyed only when the microphone circuit is closed.

When the LOCAL-REMOTE switch is set at REMOTE, the remote microphone is connected to the microphone input circuits, the local microphone is disconnected, and the coil of the signal control relay, 7, is grounded, thereby short-circuiting the coil and allowing the relay to return to the inoperative (closed) position. This permits the rectifier output of 24 volts, d. c., to light a lamp at the remote operating position, indicating that the transmitter is turned on and available for modulation from the remote operating point. When set at LOCAL, this switch disconnects the remote microphone line from the microphone transformer, connects the local microphone to the microphone transformer, and removes the ground from the coil of the signal-control relay. This energizes the coil, opening the relay contacts and extinguishing the signal lamp at the remote operating point.

In order to protect the equipment from damage caused by overloads and short circuits occurring in the power control circuits, certain key circuits are fused. The electrical locations of these fuses are shown in figure 32. The line input fuses (111-1, 111-2, 112-1, and 112-2) are of the slow-blow type and will absorb a certain amount of overload, such as when the transmitter is first turned on, for a short period of time. They will open instantaneously, however, in the event of a short circuit. Fuses 2-1 and 2-2 fuse the load voltage of transformer 117; fuses 4-1 and 4-2, the 230-volt filament supply; and fuses 3-1 and 3-2, the 230-volt primary voltage to the plate rectifier circuits.

Trouble in the power control circuits may be isolated and located by means of an operational check, tests at three key test points, and tests at five secondary test points. Visual checks are made at key test points Ⓐ and Ⓒ ; voltage checks are made at key test point Ⓑ and secondary test points (C1) , (C2) , (C3) , (C4) ,and (C5) .

LESSON PLAN NO. 11

TIME ALLOTTED: ½ HR.

SUBJECT

Power control circuits.

OBJECTIVE

To analyze the power control circuits.

INTRODUCTION

The power control circuits fuse the line input voltage and provide a means, through switch and relay action, of distributing an adjustable voltage to the various circuits of the equipment.

SUBJECT MATERIAL

1. Display Wall Chart No. 2, and point out the locations of the various circuit elements in the power control circuits.
2. Draw the simplified schematic diagram of the circuits in the power control panel on the blackboard. Refer to figure 32. Explain the functioning of these circuits. Erase the blackboard.
3. Draw the balance of figure 32 on the blackboard. Explain the operation and functioning of these circuits.
4. Point out the locations of the test points on the schematic diagram and on the equipment.

CONCLUSIONS

An operational check, three key test points, and five secondary test points aid in the trouble shooting of the power control circuits.

ORAL QUIZ

1. If the contacts of the signal-control relay do not make proper connection, will the operation of the transmitter be affected?
2. After the plate-control relay is energized, what two switches must be closed before the plate-contactor relay will be energized (closed)?
3. What is the value of the operating voltage for the signal-control relay and the plate-control relay? For the plate-contactor relay?
4. What one switch controls the output of the variable-ratio line transformer?
5. What circuits of the equipment can be energized with the POWER MAINS switch OFF (open)?

EXPERIMENT No. 10

TIME ALLOTTED: 1¾ HR.

SUBJECT

Power control circuits.

OBJECTIVE

To become familiar with the method of trouble shooting the power control circuits.

EQUIPMENT REQUIRED

One (or more) Radio Transmitter BC-640-A or BC-640-B.

For each transmitter:

Power source of 110—125-volt, or 220—250-volt, 50/60 cycle a. c.

One a-c voltmeter, 250-volt range.

One d-c voltmeter, 50-volt range.

One microphone.

INSTRUCTIONS

Make certain that the proper input power is available to the cabinet terminal board. Set POWER MAINS switch to OFF. Push PRESS OFF buttons of MASTER FILAMENTS and MASTER H. V. switches.

Remove cover from front of control panel. Set the four tumbler switches under the cover to OFF. Set LOCAL-REMOTE switch to REMOTE, and TUNE-OPERATE switch to TUNE. Remove relay cover plate from rear of control panel. Rear door of cabinet must be closed, to close the interlock switch.

PROCEDURE

1. Set POWER MAINS switch to ON. Red pilot lamp on power control panel lights, and OUTPUT VOLTAGE meter on same panel indicates 230 volts. Adjust VOLTAGE INCREASE wheel for proper meter indication. Notice that no other indicator lamps are lighted.

2. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and push PRESS ON button of MASTER H. V. switch. Set LOCAL-REMOTE switch to LOCAL. Set R. F. FILAMENTS switch to ON. Notice that pilot lamp above R. F. FILAMENTS switch lights. Open rear door of equipment and observe that filaments of tubes on oscillator, amplifier, and lower power-supply panels are lighted.

3. Set A. F. FILAMENTS switch to ON. Notice that pilot lamp above switch lights. Open rear door of cabinet and observe that filaments of tubes on modulator and upper power-supply panels are lighted. Close rear door of cabinet and make certain that interlock switch is closed.

4. Set R. F. H. V. and A. F. H. V. switches to ON. Notice that red pilot lamps above switches light.

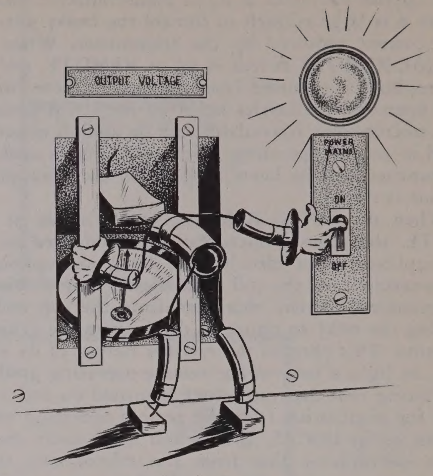
5. Set TUNE-OPERATE switch to OPERATE. If transmitter is properly tuned, a normal indication should be observed at major test point ⬠2 .

6. Test point Ⓐ : This test point checks the output of the variable-ratio line transformer and thus the load voltage to the control circuits, and is located at the OUTPUT VOLTAGE meter on power control panel. A normal indication is 230 volts.

7. Test point Ⓑ : Open rear door of cabinet. Connect a-c voltmeter, 250-volt range, between terminals 7 and 8 on rear of power control panel. (NOTE: If power input is 220—250 volts, disregard this check.) Meter should indicate 110—125 volts. Connect meter between terminals 7 and 9. Meter should indicate 220—250 volts. These two tests check the output of the autotransformer and the power input circuits.

8. Test point Ⓒ : Open rear door of cabinet. Depress interlock switch and note action of plate-control and plate-contactor relays. Note that the signal-control relay contacts are in the open position. Connect microphone, with 500-ohm, 10-watt resistor in series, across terminals 36 and 37 of cabinet terminal board. Set LOCAL-REMOTE switch to REMOTE. Notice that the signal-control relay closes. Remove microphone from terminals 36 and 37. Notice that the signal-control relay remains closed, but that the plate-control and plate-contactor relays open. Set LOCAL-REMOTE switch to LOCAL. This test provides a visual indication of the operation of the circuits on the control panel.

9. Test point (C1) : Connect a-c voltmeter, 250-volt range, between terminals 11 and 12 on rear of control panel. Meter should indicate 230 volts. This test checks the power input to the control panel and the operation of the MASTER FILAMENTS switch, input fuses, and R. F. FILAMENTS switch.



10. Test point (C2) : Connect a-c voltmeter, 250-volt range, between terminals 13 and 14. Meter should indicate 230 volts. This test checks the operation of the A.F. FILAMENTS switch.

11. Test point (C3) : Connect a-c voltmeter, 250-volt range, between terminals 19 and 20. Meter should indicate 230 volts. This test checks the MASTER H. V. switch, plate-contactor relay, fuses 3-2 and 3-1, and A. F. H. V. switch.

12. Test point (C4) : Connect a-c voltmeter, 250-volt range, between terminals 15 and 17. Meter should indicate 230 volts. This test checks the R. F. H. V. and TUNE-OPERATE switches.

13. Test point (C5) : Connect d-c voltmeter, 50-volt range, between terminals 23 and 24. Meter should indicate 24 volts, d. c. This test checks the selenium-rectifier circuits and the plate-control and signal-control relay coils.

14. The instructor will simulate trouble in the equipment. Use the procedure outlined in this experiment to locate the defect.

CONCLUSIONS

1. The transmitter is apparently operating normally but the OUTPUT VOLTAGE meter on the power control panel reads 0. What is the probable cause of trouble?

2. The transmitter is apparently operating normally, but no response is obtained on the TRANSMITTER AVAILABLE signal lamp at the remote operating position. What is the probable cause of trouble?

3. 110—120 volts, a. c., is supplied to the equipment. An a-c voltmeter is connected between terminals 7 and 8, test point Ⓑ , on the rear of the power control panel and a normal indication is observed. However, a zero voltage reading is obtained when the voltmeter is connected between terminals 7 and 9. What is the probable cause of trouble?

4. What secondary test point is used to check the input power to the control panel?

LECTURE No. 12

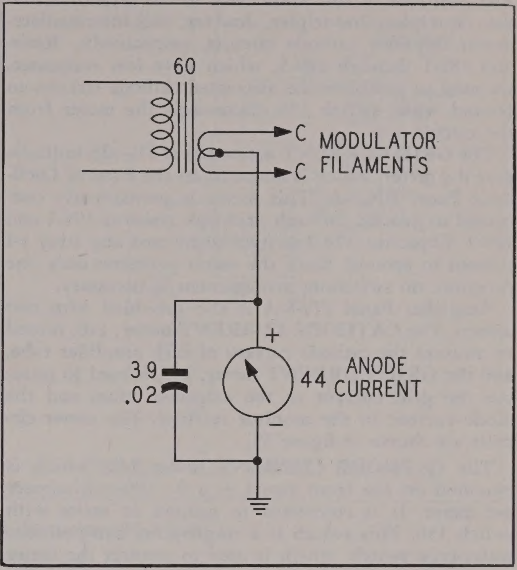
ANALYSIS OF D-C METER CIRCUITS

In the BC-640 transmitting equipment, d-c meter circuits are provided for checking each tuned circuit of the equipment. The meters are used for tuning, trouble shooting, and general testing purposes. Since the major differences between the BC-640-A and BC-640-B are in the d-c meter circuits, these circuits are discussed separately from the tuned circuits in which the meters function.

BC-640-A D-C METER CIRCUITS

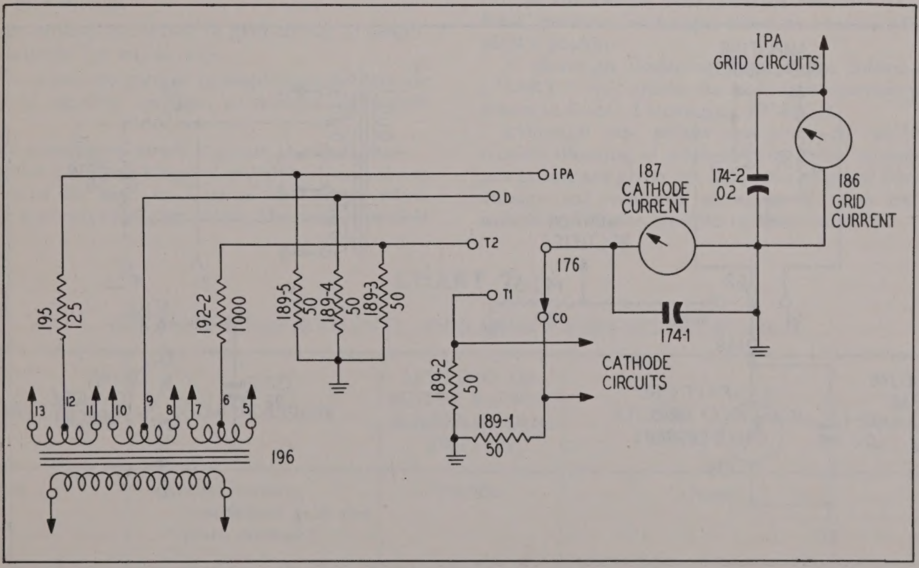
The MODULATOR ANODE CURRENT meter, a 0—200 milliampere d-c meter on the front of Modulator Panel PN-10-A, measures the combined grid and plate current (space current) of the class-B modulator tubes, and thus provides a rough indication of the modulation level. The normal indication on this meter is approximately 40 milliamperes at no signal, and approximately 108 milliamperes on voice peaks, with 850 volts, d.c., on the plates of the modulator tubes. Figure 33 shows a schematic diagram of these circuits. The meter is permanently connected from the center tap of the secondary winding of filament transformer 60 to ground, and is by-passed for radio frequencies by capacitor 39.

Oscillator Panel PN-8-A contains two meters. The CATHODE CURRENT meter, 187, is used to measure the cathode current of each tube on the panel. The GRID CURRENT meter, 186, is used to measure the current in the intermediate-power-amplifier grid circuit. A schematic diagram of the meter circuits is shown in figure 34.


60
C MODULATOR
C FILAMENTS
+
39
.02
44
ANODE CURRENT
−

TP9-120

Figure 33. Meter Circuit, Modulator Panel PN-10-A


IPA
GRID CIRCUITS
186
GRID
CURRENT
187
CATHODE
CURRENT
174-2
.02
IPA
D
T2
T1
CO
176
174-1
CATHODE
CIRCUITS
195
125
192-2
1000
189-5
50
189-4
50
189-3
50
189-2
50
189-1
50
13
12
11
10
9
8
7
6
5
196

TP9-119

Figure 34. Meter Circuits, Oscillator Panel PN-8-A

The CATHODE CURRENT meter, 187, is mounted on the front panel, and is a 0—100-milliampere d-c meter. It is by-passed for radio frequencies by capacitor 174-1. A five-position, single-pole, wafer-type switch (176) is used to connect the meter into the selected cathode circuit. This switch is mechanically coupled to the CO-T1-T2-D-IPA knob on the front of the panel. The positions of this knob refer to the crystal-oscillator, 1st-tripler, 2nd-tripler, doubler, and intermediate-power-amplifier cathode circuits, respectively. Resistors 189-1 through 189-5, which have low resistance, are used to complete the associated cathode circuits to ground when switch 176 disconnects the meter from the circuit.

The GRID CURRENT meter 186 is a 0—25-milliampere d-c meter, which is mounted on the front of Oscillator Panel PN-9-A. This meter is permanently connected to ground through grid-leak resistors 194-1 and 194-2. Capacitor 174-2 is used to by-pass any stray r-f current to ground. Since the meter performs only one function, no switching arrangement is necessary.

Amplifier Panel PN-8-A is also provided with two meters. The CATHODE CURRENT meter, 140, is used to measure the cathode current of each amplifier tube, and the GRID CURRENT meter, 139, is used to measure the grid current in the amplifier tubes and the diode current in the monitor rectifier. The meter circuits are shown in figure 35.

The CATHODE CURRENT meter 140, which is mounted on the front panel, is a 0—100-milliampere d-c meter. It is connected to ground in series with switch 150. This switch is a single-pole, two-position, wafer-type switch, which is used to connect the meter to the selected cathode circuit. It is mechanically coupled to the C1-C2 knob on the front panel. When the switch is set to the C1 position, the amplifier tube located near the rear of the chassis is selected; when set to the C2 position, the tube at the front of the chassis is selected. Resistors 143-1 and 143-2 are used in their respective circuits to complete the circuit to ground when the meter is disconnected. Capacitor 132-2 provides a low-impedance path to ground for any stray r-f current.

The GRID CURRENT meter 139, which is also mounted on the front of the amplifier panel, is a 0—25-milliampere d-c meter. It is connected to ground in series with switch 149. The switch is a single-pole, three-position, wafer-type switch, and is used to select the amplifier tube whose grid current is to be measured by meter 139, or the monitor rectifier tube whose diode current is to be measured. This switch is mechanically coupled to the G1-G2-MON. knob on the front of the panel. The G1 position selects the grid circuit of the rear amplifier tube; G2, the grid circuit of the front tube; and MON., the diode circuit of the monitor rectifier tube. Resistors 143-3, 143-4, and 143-5 are used to complete the associated circuits to ground when the meter is disconnected by switch 150.

BC-640-B D-C METER CIRCUITS

D-C metering facilities similar to those in Radio Transmitter BC-640-A are provided in the BC-640-B equipment. However, all d-c meters except one meter on Amplifier Panel PN-8-B, have been omitted. This one meter in conjunction with a five-position switch performs the functions of the other meters in the BC-640-A equipment. The meter circuits are shown in figure 36.

By observing the drawing, it can be seen that only minor circuit changes were made to delete the three meters. The circuits containing switch 176, on the oscillator panel, and switches 149 and 150, on the amplifier panel, are identical to the circuits in the BC-640-A except that the meters are omitted. The M. A. CURRENT meter, 139, is mounted on the front of the amplifier panel. A two-pole, five-position, wafer-type switch, which functions as the selector switch for the meter, is mechanically coupled to the METER RANGE

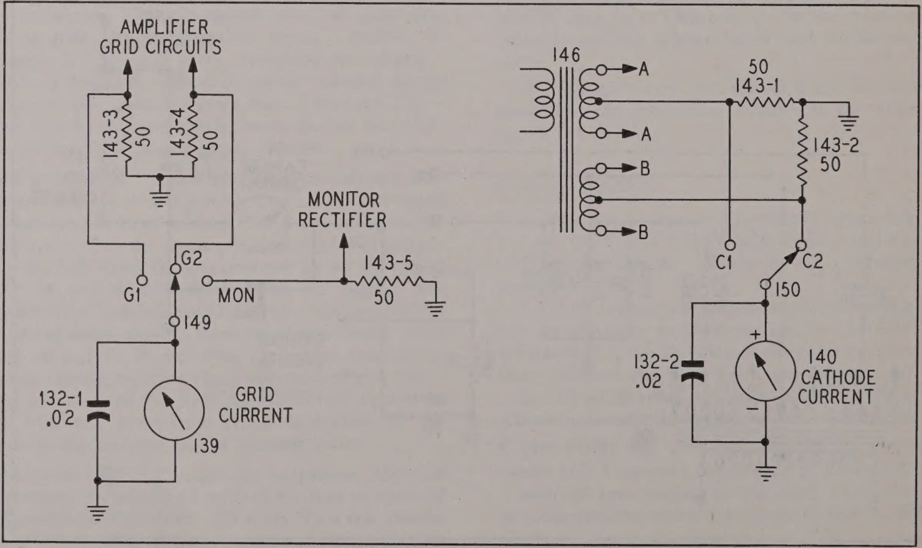


Figure 35. Meter Circuits, Amplifier Panel PN-8-A

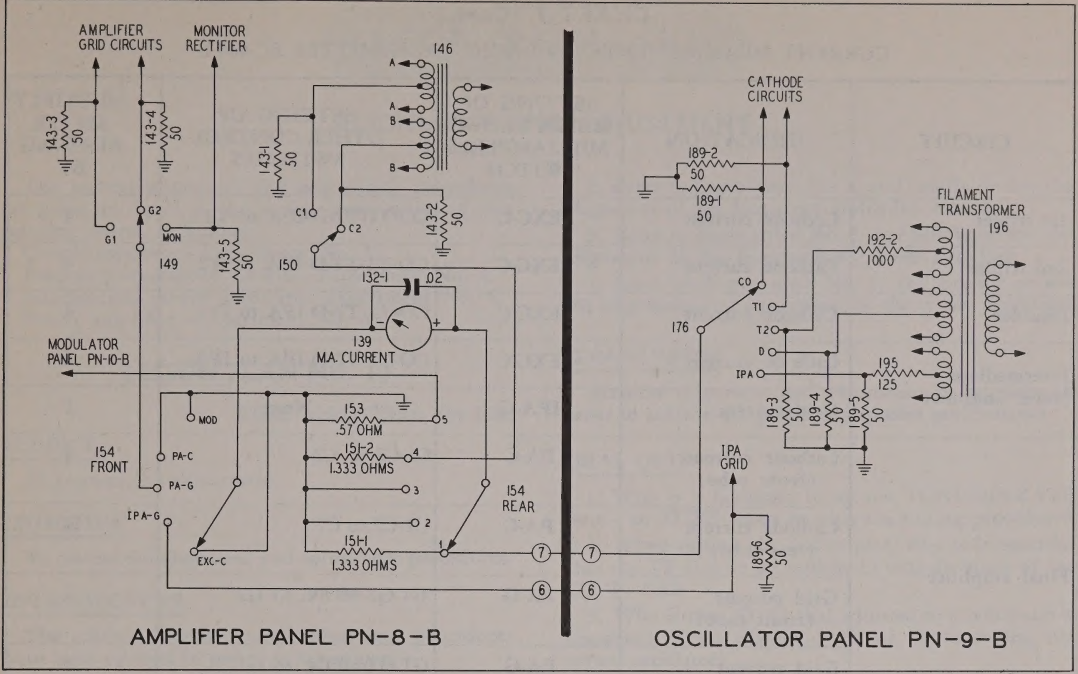

AMPLIFIER GRID CIRCUITS
MONITOR RECTIFIER
146
A
A
B
B
143-3 50
143-4 50
143-1 50
G2
G1
MON
149
143-5 50
150
C1
C2
143-2 50
132-1
.02
139
M.A. CURRENT
MODULATOR PANEL PN-10-B
153
.57 OHM
MOD
5
151-2
1.333 OHMS
4
3
2
151-1
1.333 OHMS
1
154 FRONT
PA-C
PA-G
IPA-G
EXC-C
154 REAR
7
6
AMPLIFIER PANEL PN-8-B
OSCILLATOR PANEL PN-9-B
CATHODE CIRCUITS
189-2 50
189-1 50
FILAMENT TRANSFORMER
196
192-2 1000
CO
T1
T2
D
IPA
176
195 125
189-3 50
189-4 50
189-5 50
IPA GRID
189-6 50
TP9-125

Figure 36. Meter Circuits, Radio Transmitter BC-640-B

MILLIAMPERES knob on the front panel. The functions of the meter for each position of this switch are as follows:

1. EXC-C—measures current of oscillator-panel cathode circuit selected by switch 176.
2. IPA-G—measures current in intermediate-power-amplifier grid circuit.
3. PA-G—measures current in grid circuit of amplifier tube selected by switch 149.
4. PA-C—measures current in amplifier-tube cathode circuit or in monitor rectifier, as selected by switch 150.
5. MOD.—measures anode current in modulator.

Since meter 139 has a range of only 0—25 ma., shunt resistors must be used to increase the range when measuring currents of higher value. (In certain models of the BC-640-B equipment, meter 139 is a 0—30-ma. d-c meter, which has three graduated scales.) The shunt resistors are precision wirewound resistors (151-1, 151-2 and 153), which are connected across the meter by switch 154. The range of the meter is increased four times by resistor 151-1, in the EXC-C position of the switch; four times by resistor 151-2, in the PA-C position; and eight times by resistor 153, in the MOD. position.

A thorough understanding of the information in CHART 7 will aid in the making of current measurements in Radio Transmitter BC-640-B.

Although test points are given to facilitate the trouble shooting of other circuits in the equipment, no test points are given for the meter circuits, since simple voltage and resistance measurements may be used to isolate and locate trouble in these circuits.

CHART 7

CURRENT MEASUREMENTS ON RADIO TRANSMITTER BC-640-B

CIRCUIT	INDICATION	SETTING OF METER RANGE MILLIAMPERES SWITCH	SETTING OF OTHER CONTROL SWITCHES	MULTIPLY METER READING BY
Modulator	Anode current (combined grid and plate current)	MOD.	None	8
Crystal oscillator	Cathode current	EXC-C	CO-T1-T2-D-IPA to CO	4

CHART 7 (Cont.)

CURRENT MEASUREMENTS ON RADIO TRANSMITTER BC-640-B

CIRCUIT	INDICATION	SETTING OF METER RANGE MILLIAMPERES SWITCH	SETTING OF OTHER CONTROL SWITCHES	MULTIPLY METER READING BY
1st tripler	Cathode current	EXC-C	CO-T1-T2-D-IPA to T1	4
2nd tripler	Cathode current	EXC-C	CO-T1-T2-D-IPA to T2	4
Doubler	Cathode current	EXC-C	CO-T1-T2-D-IPA to D	4
Intermediate power amplifier	Cathode current	EXC-C	CO-T1-T2-D-IPA to IPA	4
	Grid current	IPA-G	None	1
Final amplifier	Cathode current (front tube)	PA-C	C1-C2 to C2	4
	Cathode current (rear tube)	PA-C	C1-C2 to C1	4
	Grid current (front tube)	PA-G	G1-G2-MON. to G2	1
	Grid current (rear tube)	PA-G	G1-G2-MON. to G1	1
Monitor rectifier	Diode current	PA-G	G1-G2-MON. to MON.	1

LESSON PLAN NO. 12

TIME ALLOTTED: ½ HR.

SUBJECT

D-c meter circuits

OBJECTIVE

To analyze the d-c meter circuits.

INTRODUCTION

In the BC-640 transmitting equipment, d-c meter circuits are provided for checking each tuned circuit of the equipment. The meters are used for tuning, trouble shooting, and general testing purposes. Since the major differences between the BC-640-A and BC-640-B are in the d-c meter circuits, these circuits are discussed separately from the tuned circuits in which the meters function.

SUBJECT MATERIAL

1. For each meter circuit in the BC-640-A equipment:

a. Draw the simplified schematic diagram on the blackboard (refer to figures given in the lecture).

b. Point out the location of the meter on the equipment, and state the panel designation of the meter.

c. Explain the type of indication presented by the meter, and explain the circuit in which it functions.

d. Describe each component in the meter circuit and explain its function.

2. For the meter circuit in the BC-640-B equipment:

a. Draw figure 36 on the blackboard. Point out the location of the meter on the equipment and state the panel designation of the meter.

b. Describe the meter and explain the function of the meter shunt resistors.

c. Describe the METER RANGE MILLIAMPERES switch and state what circuit is associated with each setting of the switch.

d. Draw CHART 7 on the blackboard, and explain the method of obtaining current measurements.

CONCLUSIONS

Although test points are given to facilitate the trouble shooting of other circuits in the equipment, no test points are given for the meter circuits, since simple voltage and resistance measurements may be used to isolate and locate trouble in these circuits.

ORAL QUIZ

1. What are the major uses of the d-c meter circuits?

2. On the BC-640-A equipment, what meter is used to provide a rough indication of the modulation level?

3. What meter may be used to obtain a relative indication of the transmitter power output?

LECTURE No. 13

ALIGNMENT AND ADJUSTMENT

The correct alignment and adjustment procedures are given in detail in the earlier experiments of this training course, as follows:

Crystal oscillator—Experiment No. 3.
Frequency-multiplier circuits—Experiment No. 4.
Intermediate power amplifier—Experiment No. 5.
Power amplifier—Experiment No. 6.

LESSON PLAN NO. 13

TIME ALLOTTED: 1½ HR.

SUBJECT

Alignment and adjustment.

OBJECTIVE

To review the alignment and adjustment procedures.

INTRODUCTION

The correct alignment and adjustment procedures have been covered in previous experiments.

SUBJECT MATERIAL

1. Refer to Experiment No. 3, and briefly review the alignment of the crystal oscillator.
2. Refer to Experiment No. 4, and briefly review the alignment of the frequency-multiplier circuits.
3. Refer to Experiment No. 5, and briefly review the alignment of the intermediate power amplifier.
4. Refer to Experiment No. 6, and briefly review the alignment and adjustment of the power amplifier.

CONCLUSIONS

Accurate alignment and adjustment is necessary in order to achieve the proper equipment performance.

ORAL QUIZ

1. Why is it necessary to set the TUNE-OPERATE switch to TUNE when starting the tuning procedure?
2. When tuning the 2nd tripler, why is it essential that the T2 dial be set within 15 dial divisions of the CO/T1 dial?
3. Why is the CO/T1 dial adjusted to a point above resonance of the plate-tank circuit when tuning the crystal oscillator?
4. How may unbalanced power-amplifier tubes be detected while tuning the power amplifier?
5. Generally, how should an increase in grid current affect the cathode current in the power amplifier?

EXPERIMENT No. 11

The students will perform those alignment and adjustment procedures which the instructor, at his discretion, shall permit. The maximum time allotted is two hours.

LECTURE No. 14

TROUBLE SHOOTING

Quick and efficient location of trouble in an equipment requires the use of a systematic trouble-shooting procedure. The Philco trouble-shooting procedure is logical, thorough, and easy to follow. It is based upon:

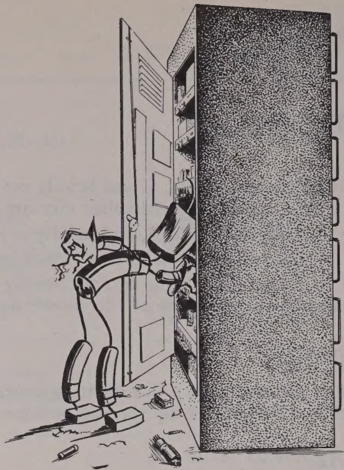
First—Localization of the trouble to a functional section, or block of circuits.

Second—Isolation of the faulty circuit within that section.

Third—Location of the defective part within that circuit.

When trouble is found to exist in the equipment, localization of the trouble to a functional section is accomplished, if possible, by a visual inspection and an operational check. The visual inspection should be made first; any apparent trouble indications, such as loose or broken wires, cables, and terminals, revealed by this inspection should be corrected. If the visual inspection does not reveal the trouble, the OPERATIONAL CHECK in Chart 5 should be made. By means of this check, the technician often can localize the trouble to a block of circuits immediately, without needless testing.

If the trouble cannot be localized by the operational check, it should be localized by the step-by-step TEST-POINT CHECK in Chart 6. Each sectional chart refers



to one or more major test points, ①, ②, etc.; a group of key test points, Ⓐ , Ⓑ , etc.; and, if required, a group of secondary test points, A1 , A2 , etc.; all test points are indicated on the schematic diagram and photographs. Tests at the major test points throughout the equipment will localize the trouble to a particular section, and eliminate other sections from suspicion.

After the trouble has been localized to a section, either by the operational check or by tests at major test points, additional tests at the key and secondary test points, specified in the chart, will isolate the faulty circuit. The defective part can then be located by testing tubes, by further voltage and resistance measurements, or by substitution of parts.

TROUBLE-SHOOTING PROCEDURE

NOTE: The following procedure is written specifically for Radio Transmitter BC-640-B. The same procedure may be used for Radio Transmitter BC-640-A, as the two equipments are identical with the exception that on Radio Transmitter BC-640-A the METER RANGE MILLIAMPERES switch is not used and additional panel meters are provided.

Perform the following preliminary steps before making the OPERATIONAL CHECK:

1. Make certain that the equipment is properly connected to a 60-cycle a-c power source of either 110—125 volts or 220—250 volts.

2. Set the POWER MAINS switch to OFF. Push the PRESS OFF buttons of the MASTER FILAMENTS and MASTER H. V. switches. Set the LOCAL-REMOTE switch to REMOTE, and the TUNE-OPERATE switch to TUNE.

3. Make certain that both neutralizing links are in place.

4. Make certain that the antenna transmission line is properly connected to the antenna jack at the rear of the amplifier panel.

5. Set all tuning controls to the readings listed on the amplifier-panel and oscillator-panel tuning charts. If these charts are not available, set the tuning controls approximately to the readings on the numerical-example tuning charts, located inside the cabinet door. These charts cannot be used for exact tuning. Refer to Lecture No. 13 for the tuning procedure.

6. Set all switches under the cover on the front of the control panel to OFF.

7. The rear door of the cabinet must be closed, to close the interlock switch.

CHART 5

OPERATIONAL CHECK

STEP	BC-640-A, B CONTROLS	NORMAL INDICATION	POSSIBLE CAUSE OF ABNORMAL INDICATION
1	Set POWER MAINS switch to ON.	Red pilot lamp on power control panel lights. OUTPUT VOLTAGE meter on same panel indicates 230 volts.	Incorrect setting of VOLTAGE INCREASE wheel or defective line input. Indicator lamp burned out. Trouble in power control panel; proceed with step 3 of TEST-POINT CHECK.
2	Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H. V. switch. Set LOCAL-REMOTE switch to LOCAL. Set R. F. FILAMENTS switch to ON.	Green pilot lamp above R. F. FILAMENTS switch lights. Filaments on oscillator, amplifier, and lower power-supply panels light.	Indicator lamp burned out. Defective transformer 97 on lower power-supply panel. If no filaments light, proceed with step 5 of TEST-POINT CHECK. If filaments light on all but one panel, trouble is in filament circuit of that panel, or in the interpanel wiring.

CHART 5 (Cont.)

OPERATIONAL CHECK

STEP	BC-640-A, B CONTROLS	NORMAL INDICATION	POSSIBLE CAUSE OF ABNORMAL INDICATION
3	Set A. F. FILAMENTS switch to ON.	Green pilot lamp above switch lights. Filaments on modulator and upper power-supply panels light.	Indicator lamp burned out. Defective transformer 97 on upper power-supply panel. If no filaments light, proceed with step 5 of TEST-POINT CHECK. If filaments are not lighted on one panel only, trouble is in filament circuit of that panel, or in the interpanel wiring.
4	Set R. F. H. V. and A. F. H. V. switches to ON.	Red pilot lamps above switches light.	Defective transformer 98 on power-supply panel. Indicator lamp burned out. Trouble in equipment; proceed with step 1 of TEST-POINT CHECK. If indication is normal in step 1, proceed with step 7.
5	Set TUNE-OPERATE switch to OPERATE. Set METER RANGE MILLIAMPERES switch to PA-G, and G1-G2-MON. switch to MON.	M. A. CURRENT meter indicates more than 1 ma. (For Radio Transmitter BC-640-A, take this reading on the GRID CURRENT meter on amplifier panel.)	Incorrect tuning or neutralization. Trouble in equipment; proceed with step 1 of TEST-POINT CHECK. If indication is normal in step 1, proceed with step 14.
6	Set METER RANGE MILLIAMPERES switch to MOD. Plug headset into MONITOR jack, and plug microphone into MICROPHONE NO. 1 jack. Talk into microphone.	M. A. CURRENT meter indicates 40 ma. at no signal, and approximately 108 ma. on voice peaks. (For Radio Transmitter BC-640-A, take this reading on MODULATOR ANODE CURRENT METER on modulator panel.)	Improperly adjusted VOLUME CONTROL. Trouble in equipment; proceed with step 1 of TEST-POINT CHECK. If indication is normal in step 1, proceed with step 22.
		Voice is heard in headset.	If meter indication is normal, but voice is not heard, trouble is in monitor-rectifier circuits.

NOTE: If the equipment functions normally for local operation in the OPERATIONAL CHECK but abnormally for remote operation, trouble is in the remoting lines or remote control equipment.

The following test equipment is required for the TEST-POINT CHECK.

One a-c voltmeter, 250-volt range.

One d-c voltmeter, 30-volt and 1000-volt ranges.

One oscilloscope.

The d-c voltmeter should have a sensitivity of 1000 ohms per volt or greater; the a-c voltmeter, a sensitivity of 200 ohms per volt or greater.

CHART 6 TEST-POINT CHECK

POWER-SUPPLY CIRCUITS

Power Control Panel, Control Panel, and Power-Supply Panels (Over-all Check)

(See figure 37 for location of test point.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
1	1 (Terminal 17)	Connect d-c voltmeter (1000-volt scale) from test point to terminal 14. (This test must be made on each one of the two power-supply panels.)	Set POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute then push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Set TUNE-OPERATE switch to OPERATE, and LOCAL-REMOTE switch to LOCAL.	780 to 850 volts.	If indication is normal on both panels, proceed with step 13; otherwise proceed with step 4.	Trouble in power-supply circuits. If indication is abnormal on both panels, proceed with step 2. If indication is abnormal on one panel only, proceed with step 4.

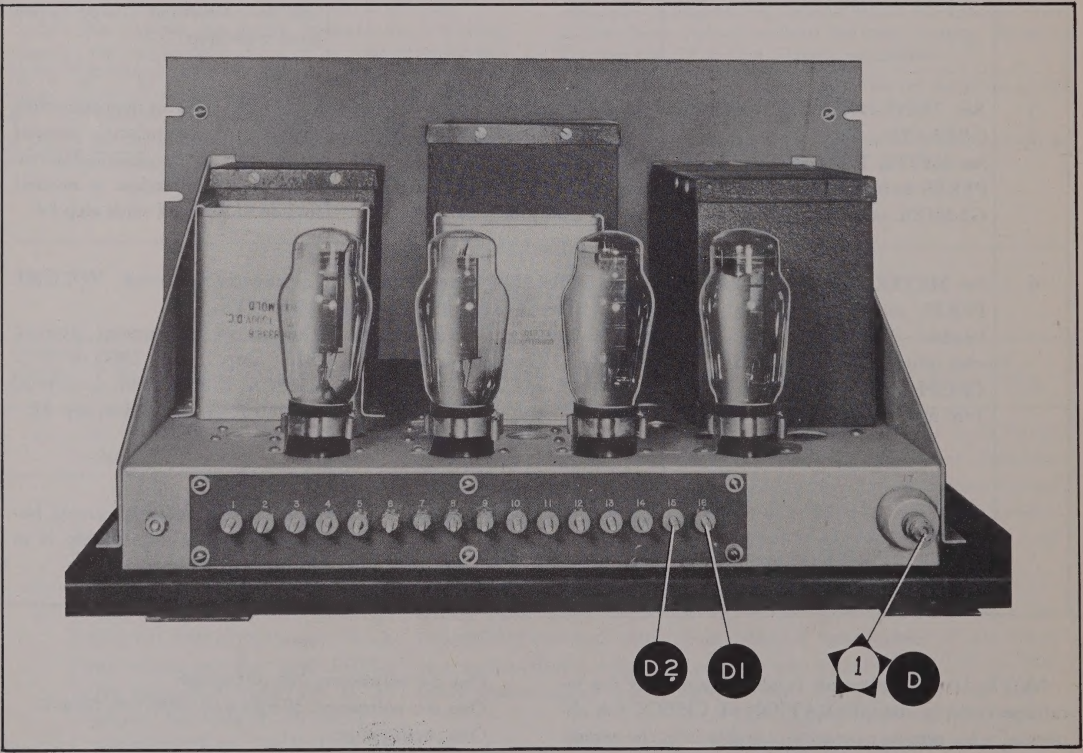


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Figure 37. Power-Supply Panel PN-12-A, Rear View, Showing Test Points

CHART 6 TEST-POINT CHECK (Cont.)

POWER CONTROL PANEL

(See figures 38 and 40 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
2	Ⓐ (OUTPUT VOLTAGE meter)	None.	Push PRESS OFF button of MASTER FILAMENTS switch. Rotate VOLTAGE INCREASE wheel for proper indication on OUTPUT VOLTAGE meter.	230 volts.	Proceed with step 4.	Check input power. Trouble in power control panel. If line input is 110—125 volts, proceed with part 1 of step 3. If line input is 220—250 volts, proceed with part 2 of step 3.
3 (part 1)	Ⓑ (Terminal 9)	Connect a-c voltmeter (250-volt scale) from test point to terminal 8 on rear of power control panel.	No change.	110 to 125 volts.	Proceed with part 2 of this step.	Check input power, panel or inter-panel wiring, fuse 111-1 or 111-2, or switch 116.
3 (part 2)		Connect a-c voltmeter (250-volt scale) from test point to terminal 7 on rear of power control panel.		220 to 250 volts.	Defective autotransformer 117, meter 113, or associated wiring.	Check fuses 112-1 or 112-2, switch 116, panel and interpanel wiring, and autotransformer.

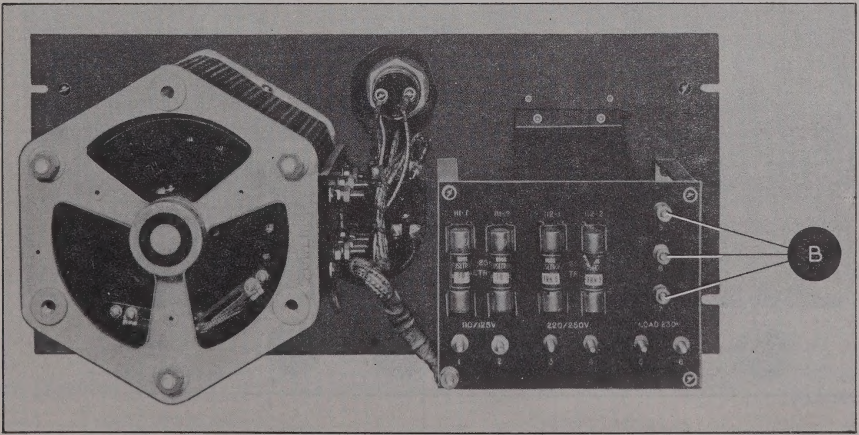

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Figure 38. Power Control Panel, Rear View, Showing Test Point

CHART 6 TEST-POINT CHECK (Cont.)

CONTROL PANEL

(See figure 39 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
4	C (Visual check)	None.	Set POWER MAINS switch to OFF. Push PRESS ON buttons of MASTER FILAMENTS and MASTER H.V. switches. Open rear door and remove cover from relays 7 and 8. Set POWER MAINS switch to ON. Set LOCAL-REMOTE switch to LOCAL. Set TUNE-OPERATE switch to OPERATE. Depress interlock switch.	Relays 6, 7, and 8 all close. Two red and two green pilot lamps on control panel remain lighted in both positions of TUNE-OPERATE switch.	Proceed with step 11.	Trouble in control panel; proceed with step 5.
5	C1 (Terminals 11 and 12)	Connect a-c voltmeter (250-volt scale) between terminals at test point.	No change.	230 volts.	Proceed with step 6.	Check fuses 4-1, 4-2, 2-1, and 2-2, switches 15-1 and 13-1, and panel and interpanel wiring.

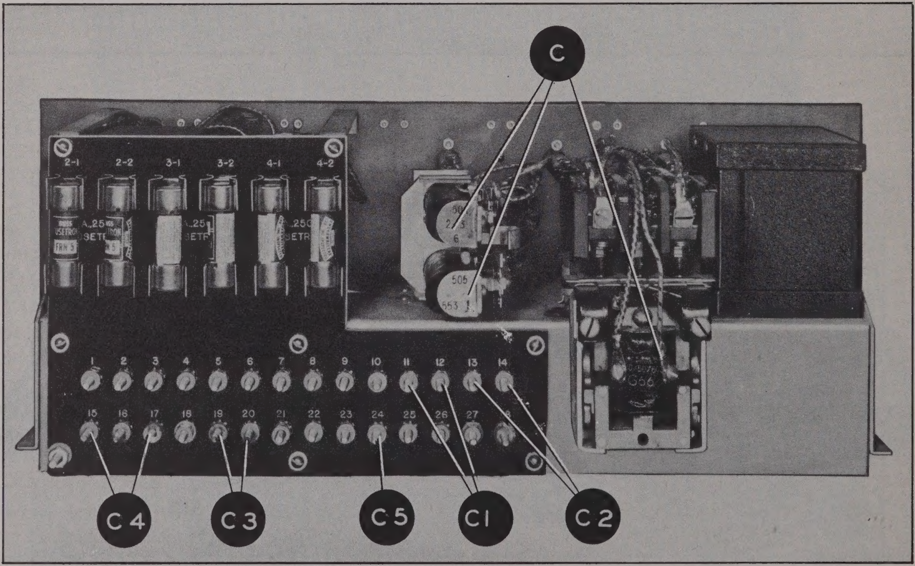

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Figure 39. Control Panel PN-11-A, Rear View, Cover Removed From Relays 6 and 7, Showing Test Points

CHART 6 TEST-POINT CHECK (Cont.)

CONTROL PANEL

(See figure 39 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
6	C2 (Terminals 13 and 14)	Connect a-c voltmeter (250-volt scale) between terminals at test point.	No change.	230 volts.	Proceed with step 7.	Check switch 15-2.
7	C3 (Terminals 19 and 20)	Connect a-c voltmeter (250-volt scale) between terminals at test point.	No change.	230 volts.	Proceed with step 8.	Check fuses 3-1 and 3-2, interlock switch, switch 55, switches 13-2 and 15-4, relays 6 and 8, and panel and interpanel wiring.
8	C4 (Terminals 15 and 17)	Connect a-c voltmeter (250-volt scale) between terminals at test point.	Set TUNE-OPERATE switch to TUNE.	230 volts.	Proceed with step 9.	Check switches 15-3 and 14.
9	C5 (Terminal 24)	Connect d-c voltmeter (30-volt scale) from test point to terminal 23.	Set TUNE-OPERATE switch to OPERATE, and LOCAL-REMOTE switch to LOCAL.	24 volts.	Check panel and interpanel wiring.	Check transformer 16, rectifier 12, relays 7 and 8, capacitors 1-1, 1-2, 1-3, and 1-4, choke 9, and resistor 11.
POWER-SUPPLY PANELS (See figure 37 for locations of test points.)						
10	D (Terminal 17)	Connect d-c voltmeter (1000-volt scale) from test point to terminal 14. (Make this test on the power-supply panel that gave an abnormal indication in step 1.)	No change.	780 to 850 volts.	Proceed with step 11.	Check VT145's, choke 94-1, capacitors 91 and 92, transformers 97 and 98, and associated panel and interpanel wiring. (Low voltage may be caused by overload in circuits supplied from terminal 17.)
11	D1 (Terminal 16)	Connect d-c voltmeter (1000-volt scale) from test point to terminal 14.	No change.	380 to 410 volts.	Proceed with step 12.	Check choke 94-2, capacitor 92, and associated circuits.

CHART 6 TEST-POINT CHECK (Cont.)

POWER-SUPPLY PANELS

(See figure 37 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
12	D2 (Terminal 15)	Connect d-c voltmeter (1000-volt scale) from test point to terminal 14.	No change.	270 to 350 volts.	Check interpanel wiring. If wiring is found serviceable, proceed with step 13.	Check resistors 95-1 and 96, and associated wiring.

R-F CIRCUITS

Oscillator Panel and Amplifier Panel (Over-all Check)

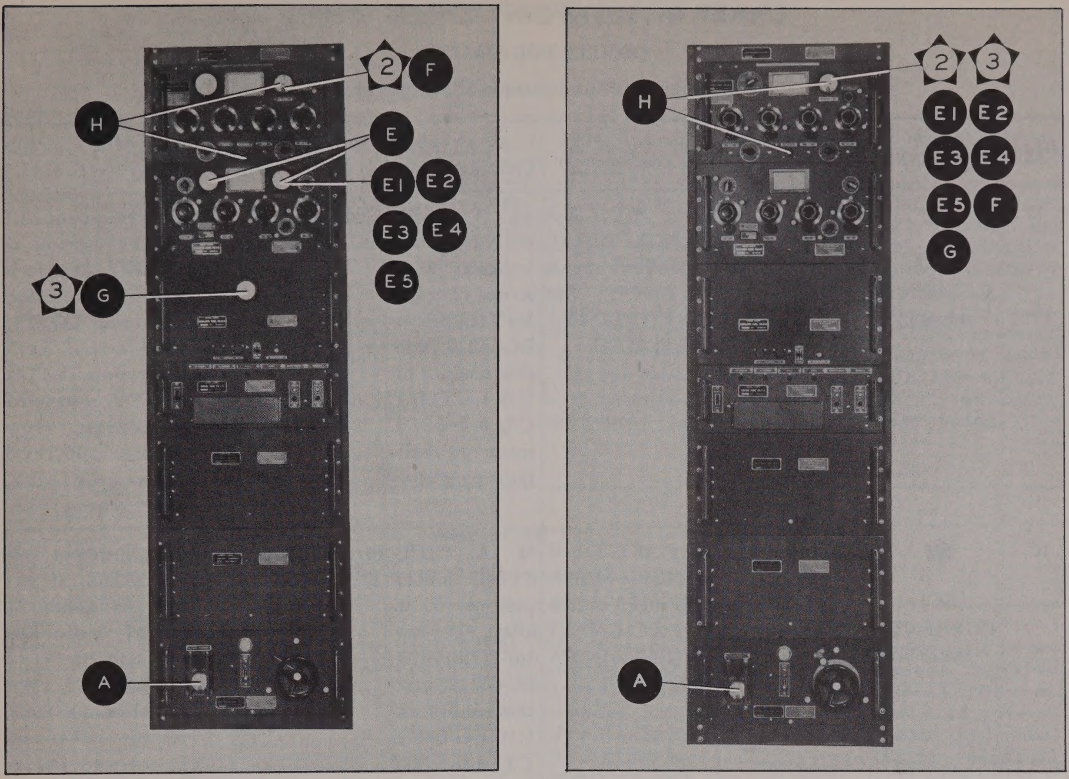
(See figure 40 for location of test point.)

13	2 (M.A. CURRENT meter)	None required.	Set METER RANGE MILLIAMPERES switch to PA-G, and G1-G2-MON. switch to MON.	M. A. CURRENT meter indicates more than 1 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.)	Proceed with step 21.	Trouble in r-f circuits; proceed with step 14.

OSCILLATOR PANEL

(See figure 40 for locations of test points.)

14 (part 1)	E (M.A. CURRENT meter)	None required.	Set POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute then push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Set TUNE-OPERATE switch to OPERATE. Set METER RANGE MILLIAMPERES switch to EXC-C. Set CO-T1-T2-D-IPA switch to IPA. Set LOCAL-REMOTE switch to LOCAL.	M. A. CURRENT meter indicates 50 to 70 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.)	Proceed with part 2 of this step.	Maladjustment of IPA control; if unable to obtain normal indication by tuning IPA, check meter, switches 154 and 176, capacitor 132-1, resistors 195 and 151-1, and meter-circuit panel and interpanel wiring. If these components are found serviceable, trouble is in oscillator panel; proceed with step 15 to isolate.



150 150A

Figure 40. Radio Transmitter BC-640-A (Left) and Radio Transmitter BC-640-B (Right), Front Views, Showing Test Points

CHART 6 TEST-POINT CHECK (Cont.)

OSCILLATOR PANEL

(See figure 40 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
14 (part 2)		None required.	Set METER RANGE MILLIAMPERES switch to IPA-G.	M. A. CURRENT meter indicates more than 7 ma. (For Radio Transmitter BC-640-A, take this reading on GRID CURRENT meter on oscillator panel.)	Proceed with step 20.	Check neutralization of i.p.a.; then repeat both parts of this step. If indication is still abnormal, proceed with step 15.

CHART 6 TEST-POINT CHECK (Cont.)

OSCILLATOR PANEL

(See figure 40 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
15	E1 (M.A. CURRENT meter)	None required.	Set METER RANGE MILLIAMPERES switch to EXC-C. Set CO-T1-T2-D-IPA switch to CO.	M. A. CURRENT meter indicates 30 to 40 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.)	Proceed with step 16.	Maladjustment of CO/T1 control; if unable to obtain a normal indication by tuning CO/T1, check crystal, oscillator tube VT175 or VT66, associated components, transformer 196, and panel and interpanel wiring.
16	E2 (M.A. CURRENT meter)	None required.	Set METER RANGE MILLIAMPERES switch to EXC-C. Set CO-T1-T2-D-IPA switch to T1.	M. A. CURRENT meter indicates 30 to 40 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.)	Proceed with step 17.	Maladjustment of T1 control; if unable to obtain a normal indication by tuning T1, check VT100, associated components, resistor 189-1, and panel and interpanel wiring.
17	E3 (M.A. CURRENT meter)	None required.	Set CO-T1-T2-D-IPA switch to T2.	M. A. CURRENT meter indicates 45 to 60 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.)	Proceed with step 18.	Maladjustment of T2 control; if unable to obtain a normal indication by tuning T2, check 2nd-tripler tube VT204, associated components, resistors 189-2 and 192-2, and panel and interpanel wiring.
18	E4 (M.A. CURRENT meter)	None required.	Set CO-T1-T2-D-IPA switch to D.	M. A. CURRENT meter indicates 55 to 65 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.)	Proceed with step 19.	Maladjustment of D control; if unable to obtain a normal indication by tuning D, check doubler tube VT204, associated components, resistor 189-3, and panel and interpanel wiring.

CHART 6 TEST-POINT CHECK (Cont.)

OSCILLATOR PANEL

(See figure 40 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
19	E 5 (M.A. CURRENT meter)	None required.	Set **CO-T1-T2-D-IPA** switch to IPA.	M. A. CURRENT meter indicates 50 to 70 ma. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on oscillator panel.)	Recheck neutralization. If i.p.a. cannot be neutralized, check neutralizing circuit, by-pass capacitors, and panel and interpanel wiring. If these components are found to be serviceable, proceed with step 20.	Maladjustment of IPA control; if unable to obtain a normal indication by tuning IPA, check i.p.a. tube VT204, associated components, resistor 189-4, and panel and interpanel wiring.

AMPLIFIER PANEL

(See figure 40 for location of test point.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
20 (part 1)	F (M.A. CURRENT meter)	None required.	Set METER RANGE MILLIAMPERES switch to PA-C, and C1-C2 switch to C1 and then C2.	M. A. CURRENT meter indicates at least 40 ma., and varies less than 10 ma. when C1-C2 switch is varied from one position to the other. (For Radio Transmitter BC-640-A, take this reading on CATHODE CURRENT meter on amplifier panel.)	Proceed with part 2 of this step.	Tuning. Unbalanced or defective amplifier tubes VT204 or associated components; check transformer 146, switch 150, resistors 151-2, 143-1, 143-2, and 189-6, capacitors 121-1 through 121-4, and panel and interpanel wiring.
20 (part 2)			Set METER RANGE MILLIAMPERES switch to PA-G, and set G1-G2-MON. switch to G1 and then G2.	M. A. CURRENT meter indicates at least 10 ma., and varies less than 3 ma. when G1-G2-MON. switch is varied from one position to the other. (For Radio Transmitter BC-640-A, take this reading on GRID CURRENT meter on amplifier panel.)	Proceed with step 21.	Check neutralization of amplifier, then repeat both parts of this step. If indication is still abnormal, check resistor 143-3, 143-4, and 144-1 through 144-4, amplifier tubes VT204 and associated circuits, and panel and interpanel wiring. If amplifier cannot be neutralized, check neutralizing circuits.

CHART 6 TEST-POINT CHECK (Cont.)

AUDIO AND MODULATOR CIRCUITS

Modulator Panel

(See figures 40 and 41 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
21	3 (M.A. CURRENT meter)	None required.	Set POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H. V. switch. Set TUNE-OPERATE switch to OPERATE, and LOCAL-REMOTE switch to LOCAL. Depress interlock switch. Set METER RANGE MILLIAMPERES switch to MOD. Plug headset into MONITOR jack, and plug microphone into MICROPHONE NO. 1 jack. Talk into microphone.	M. A. CURRENT meter indicates 40 ma. at no signal, and indicates approximately 108 ma. on voice peaks. (For Radio Transmitter BC-640-A, take this reading on MODULATOR ANODE CURRENT meter on modulator panel.) Voice heard in headset.	Trouble-shooting procedure is complete.	If meter indication is abnormal, trouble is in modulator panel; proceed with step 22. If meter indication is normal, but voice is not heard, trouble is in monitor-rectifier circuit.
22	G (M.A. CURRENT meter)	None required.	Remove microphone. Short-circuit terminals 11 and 12 on rear of modulator panel.	M. A. CURRENT meter indicates approximately 110 ma. (For Radio Transmitter BC-640-A, take this reading on MODULATOR ANODE CURRENT meter on modulator panel.) Relay 42 closed.	Check microphone jack, microphone, switch 55, relays 7 and 8, transformer 56, and associated input circuits.	Check adjustment of volume control 52; if this adjustment is correct, proceed with step 23.
23	G1 (Pin 5 of socket 62-1)	Connect oscilloscope from test point to ground.	Same as step 22 except set POWER MAINS switch to OFF, remove speech-amplifier tubes VT94 from sockets 62-1 and 62-2, and set POWER MAINS switch to ON.	1000-cycle undistorted sine-wave pattern on oscilloscope.	Proceed with step 24.	Check oscillator tube VT94, relay 42, volume controls 52 and 53, oscillator components, and input circuit of amplifier tube in socket 62-1.

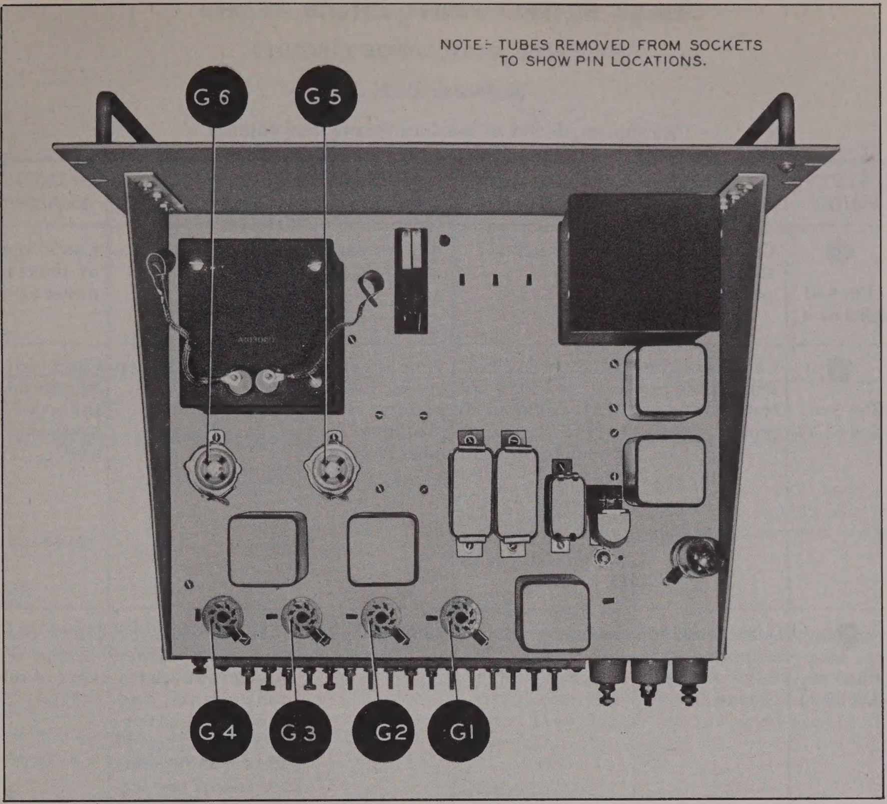


Figure 41. Modulator Panel PN-10-B, Top View, Showing Test Points

CHART 6 TEST-POINT CHECK (Cont.)

AUDIO AND MODULATOR CIRCUITS

Modulator Panel

(See figures 40 and 41 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
24	G2 (Pin 5 of socket 62-2)	Connect oscilloscope from test point to ground.	Same as step 23.	Same as step 23.	Proceed with step 25.	Check input circuit of speech-amplifier tube in socket 62-2.
25	G3 (Pin 5 of socket 62-3)	Connect oscilloscope from test point to ground.	Same as step 22 except set POWER MAINS switch to OFF, remove driver tubes VT175 or VT66 (replace speech-amplifier tubes), and set POWER MAINS switch to ON.	Same as step 23, but oscilloscope pattern is approximately 16 times larger.	Proceed with step 26.	Check speech-amplifier tubes, transformer 57, associated circuits, and input circuit of driver tube in socket 62-3.

CHART 6 TEST-POINT CHECK (Cont.)

AUDIO AND MODULATOR CIRCUITS

Modulator Panel

(See figures 40 and 41 for locations of test points.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
26	G4 (Pin 5 of socket 62-4)	Connect oscilloscope from test point to ground.	Same as step 25.	Same as step 25.	Proceed with step 27.	Check input circuit of driver tube in socket 62-4.
27	G5 (Pin 3 of socket 63-1)	Connect oscilloscope between test point and ground.	Same as step 22 except set POWER MAINS switch to OFF. Remove modulator tubes in sockets 63-1 and 63-2 (replace driver tubes), and then set POWER MAINS switch to ON.	Same as step 26, but oscilloscope pattern is approximately 4 times larger.	Proceed with step 28.	Check driver tubes, transformer 58, associated components, and input of tube.
28	G6 (Pin 3 of socket 63-2)	Connect oscilloscope between test point and ground.	Same as step 27.	Same as step 27.	Check modulator tubes, transformer 59, and associated components, and panel and interpanel wiring. If these components are found serviceable, check meter, switch 154, capacitor 132-1, and resistor 153.	Check transformer 58, and wiring to input of tube.

MONITOR RECTIFIER CIRCUITS

Amplifier Panel

(See figure 40 for location of test point.)

29	H	None required.	Plug headset into MONITOR jack. Plug microphone into MICROPHONE NO. 1 jack. Set POWER MAINS switch to ON. Push PRESS ON button of MASTER FILAMENTS switch. Wait one minute and then push PRESS ON button of MASTER H. V. switch. Depress interlock switch. Set TUNE-OPERATE	Voice is heard in headset.	End of troubleshooting procedure.	Check monitor-rectifier tube VT94 and associated components, and panel and interpanel wiring.

CHART 6 TEST-POINT CHECK (Cont.)

MONITOR RECTIFIER CIRCUITS

Amplifier Panel

(See figure 40 for location of test point.)

STEP	TEST POINT	TEST EQUIPMENT	BC-640-A, B CONTROLS	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
29 (cont.)			switch to OPERATE, and LOCAL-REMOTE switch to LOCAL. Talk into microphone.			

LESSON PLAN NO. 14

TIME ALLOTTED: 4 HR.

SUBJECT

Trouble shooting.

OBJECTIVE

To become familiar with the over-all method of localizing, isolating, and locating trouble in the equipment.

INTRODUCTION

Trouble in the equipment should be located and corrected by means of a systematic procedure.

SUBJECT MATERIAL

1. State the value of making a preliminary search for trouble by means of a visual inspection.

2. Referring to CHART 5, state each step of the OPERATIONAL CHECK, and explain the objective of each step. Make use of the blackboard and wall charts, as required.

3. Referring to CHART 6, state each step of the TEST-POINT CHECK, and explain the objective of each step. Make use of the blackboard and wall charts, as required.

CONCLUSIONS

For all practical purposes, the trouble-shooting procedure outlined in this lesson is the same analytical procedure that is followed by a skilled and experienced radio technician when shooting trouble in this equipment, even though the technician may not be aware of this fact.

ORAL QUIZ

1. What is the value of a visual inspection? Why is this inspection made first?

2. What is the value of the operational check?

3. What are the advantages of following a systematic trouble-shooting procedure?

EXPERIMENT No. 12

TIME ALLOTTED: 4 HR.

SUBJECT

Trouble shooting.

OBJECTIVE

To become familiar with the over-all method of localizing, isolating, and locating trouble in the equipment.

EQUIPMENT REQUIRED

One (or more) Radio Transmitter BC-640-A or BC-640-B.

For each transmitter:

One suitable antenna (or dummy).
One d-c voltmeter, 30-volt and 1000-volt ranges.
One a-c voltmeter, 250-volt scale.
One oscilloscope.
One single-button carbon microphone.
One headset.

INSTRUCTIONS

Complete the preliminary steps for the OPERATIONAL CHECK.

PROCEDURE

Request the instructor to place as many troubles in the equipment, one at a time, as time permits. By means of visual inspection, operational checks, tests at the test points, and further voltage and resistance measurements, as required, localize, isolate, and locate the trouble. Restore the transmitter to its original condition.

CONCLUSIONS

1. Name the three major test points and give the normal indication at each.

2. An abnormally low voltage is obtained at test point 1 on the lower power-supply panel. Further checks indicate that the components contained in this panel are serviceable. What is the most logical test to make next?

3. The equipment is apparently operating normally, but the indicator lamp above the R.F.H.V. switch is out. When the lamp is tested it is found to be good. What is the probable cause of trouble?

LECTURE No. 15

PREVENTIVE MAINTENANCE

The operating efficiency of the BC-640 equipment is largely dependent upon the effectiveness with which the preventive-maintenance inspection program is carried out. The following procedure is a suggested preventive-maintenance program for this equipment.

DAILY INSPECTION

1. Make a visual inspection of the equipment.

2. Perform the steps in the operational check, as outlined in CHART 5.

3. Check the tuning of all stages.

MONTHLY INSPECTION

1. Make a visual inspection of the equipment.

2. Generally clean and inspect the cabinet and housings.

3. Clean and dust all chassis units, terminal boards, fuse blocks, and meters. Note: The relays and switches in the equipment are self-cleaning. Do not attempt to clean them. If an air hose is used to blow dust and dirt from the cabinet, make certain that the compressed air supply is free from water, and that the pressure is not great enough to bend the capacitor plates.

4. Tighten all mounting bolts, panel screws, and control-knob setscrews.

5. Test all tubes; replace as necessary.

6. Lubricate the ANODE tuning capacitor as follows: Wipe vertical guide pins clean with cloth. Grease with vaseline and wipe clean again. Note: all other movable parts are sufficiently lubricated for the lifetime of the equipment. However, if careful inspection reveals that lubrication is necessary, use AXS-637 grease, or equal, very sparingly. Do not allow grease to get on any tuned-circuit component in the transmitter.

7. Perform steps 2 and 3 of the daily inspection.

SEMIANNUAL INSPECTION

1. Exterior of equipment: Inspect, tighten, and clean the cabinet, control knobs, meters, switches, dials, and dial locks.

2. Adjust meters for zero indication, with all power removed from transmitter. Tap lightly on meter case with tips of fingers before making adjustment.

3. Interior of equipment: Inspect, tighten and clean all tubes, sockets, capacitors, resistors, shaft connectors, plugs and jacks, coils, insulators, transformer and choke housings, terminal boards, and solder connections.

4. Test all tubes; replace as necessary.

5. Check tube-socket-pin voltages.

6. Check power-supply voltages.

7. Check waveforms at test points G1, G2, G3, G4, G5, and G6.

8. Perform step 6 of the monthly inspection, if necessary.

9. Inspect and clean the transmission lines and insulators.

10. Inspect the antenna installation (poles, mounting fixtures, etc.).

11. Reassemble the equipment, tune and adjust the transmitter, and check its over-all operation.

LESSON PLAN NO. 15

TIME ALLOTTED: ½ HR.

SUBJECT

Preventive maintenance.

OBJECTIVE

To become familiar with the preventive-maintenance procedure.

INTRODUCTION

The operating efficiency of the BC-640 equipment is largely dependent upon the effectiveness with which the preventive-maintenance inspection program is carried out. The following procedure is a suggested preventive-maintenance program for this equipment.

SUBJECT MATERIAL

1. Explain the steps in each of the following inspections:
   a. Daily.
   b. Monthly.
   c. Semiannual.

2. Stress the importance of unfailing performance of scheduled preventive-maintenance inspections.

CONCLUSIONS

Service interruptions will be minimized by an efficient, definite inspection program, which must be followed out. Hit-or-miss techniques cannot be applied.

ORAL QUIZ

1. Why is it necessary to test tubes during a preventive-maintenance inspection, even though the equipment is apparently operating normally?

2. Why is the preventive-maintenance inspection program important?

EXPERIMENT No. 13

TIME ALLOTTED: 3 HR.

SUBJECT

Preventive maintenance.

OBJECTIVE

To become familiar with the preventive-maintenance program.

EQUIPMENT REQUIRED

One (or more) Radio Transmitter BC-640-A or BC-640-B with accessory components as listed in previous experiments. One tube checker for each equipment.

INSTRUCTIONS

Do not rush this experiment. While following the steps outlined in the procedure, take time to study the mechanical details of the equipment.

PROCEDURE

1. Perform the daily inspection.
2. Perform the semiannual inspection.

CONCLUSIONS

1. Why is it necessary to perform the operational check after completing each preventive-maintenance inspection?

2. Why is it necessary to tap on the meter case before making the zero adjustment?

LECTURE No. 16

SPECIAL INFORMATION

A modification, given in Technical Order AN 08-40BC640-21, entails a change in Oscillator Panel PN-9-A which permits the use of crystal units having either a ¾-inch or ½-inch prong spacing, instead of a ¾-inch spacing only. This modification applies only to Radio Transmitter BC-640-A. Details are given in the Technical Order mentioned above.

CHART 7 gives a summary of some of the radio sets in which the BC-640 equipment is employed as a basic radio component.

Additional information concerning the BC-640-A and BC-640-B transmitting equipment may be obtained by reference to Technical Order AN 16-40 BC640-2.

LESSON PLAN NO. 16

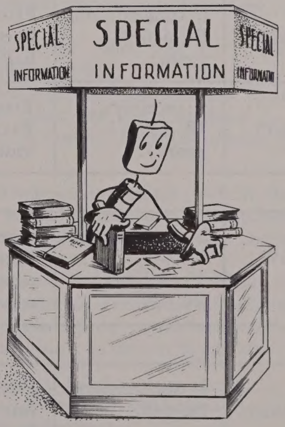
TIME ALLOTTED: ¼ HR.

SUBJECT

Special information.

OBJECTIVE

To note a few items of special information.



INTRODUCTION

There are certain facts concerning this equipment which must be presented to complete the course.

SUBJECT MATERIAL

1. State the modification in Oscillator Panel PN-9-A.

2. Discuss the applications of the BC-640 transmitting equipment as shown in CHART 7.

3. Display copies of Technical Order AN-16-40 BC640-2, if they are available.

CONCLUSIONS

A modification was made in the BC-640-A equipment so that two different standard crystal units could be used with Oscillator Panel PN-9-A.

CHART 7

APPLICATIONS OF RADIO TRANSMITTERS BC-640-A AND BC-640-B

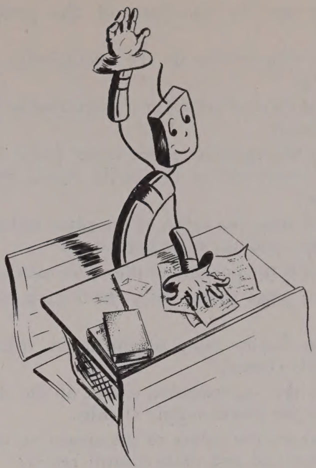
RADIO SET	COMPONENTS	USE
SCR-562	6 transmitters, BC-640 (1 spare).	Mobile transmitting station for ground control of interceptor pursuit operations. Part of Control Net System SCS-2; provides five independent channels. Uses half-wave dipoles on 90-foot steel mast.
SCR-563	6 receivers, BC-639 (1 spare).	Mobile receiving station for ground control of interceptor pursuit operations. Part of Control Net System SCS-2. Used with, but not part of SCR-562. Provides five independent channels. Uses half-wave dipoles on 90-foot steel mast.
SCR-567	2 transmitters, BC-640. 2 receivers, BC-639.	Mobile forward relay station for ground control of interceptor pursuit operations. Part of Control Net System SCS-2. Provides two independent transmitting and receiving channels for extending the range of SCR-562 and SCR-563.
SCR-573	2 transmitters, BC-640.	Mobile two-channel transmitting station for ground control of interceptor pursuit operations. Part of Control Net System SCS-3. Uses half-wave dipoles on 75-foot plywood mast.
SCR-574	2 receivers, BC-639.	Mobile two-channel receiving station for ground control of interceptor pursuit operations. Part of Control Net System SCS-3. Used with, but not part of SCR-573. Uses half-wave dipoles on 75-foot plywood mast.
SCR-632	6 transmitters, BC-640 (1 spare).	Fixed transmitting station for ground control of interceptor pursuit operations. Part of Control Net System SCS-2. Provides five independent channels. Uses half-wave dipoles on 90-foot steel mast.
SCR-633	6 receivers, BC-639 (1 spare).	Fixed receiving station for ground control of interceptor pursuit operations. Part of Control Net System SCS-2. Used with, but not part of SCR-632. Provides five independent channels. Uses half-wave dipoles on 90-foot steel mast.
SCR-637	2 transmitters, BC-640. 2 receivers, BC-639.	Fixed forward relay station for ground control of interceptor pursuit operations. Part of Control Net System SCS-2. Provides two independent transmitting and receiving channels for extending the range of SCR-562 and SCR-563. Uses half-wave dipoles on 50-foot steel mast.
SCR-643	2 transmitters, BC-640.	Fixed two-channel transmitting station for ground control of interceptor pursuit operations. Part of Control Net System SCS-3. Uses half-wave dipoles on 90-foot steel mast.
SCR-644	2 receivers, BC-639.	Fixed two-channel receiving station for ground control of interceptor pursuit operations. Part of Control Net System SCS-3. Used with, but not part of SCR-643. Uses half-wave dipoles on 90-foot steel mast.

REVIEW No. 2

Review the important points in Lectures No. 8 through No. 16 and Experiments No. 7 through No. 13 by reviewing the questions in the Oral Quiz of each Lesson Plan and in the Conclusions of each Experiment. Fully explain the answers to those questions which cause the students difficulty, and permit the students to ask questions of their own. Allow classroom discussion on questions within reasonable limits of time. Make a written note of the questions which cause general difficulty. The normal time allotment for this review is three hours.

FINAL REVIEW

Referring to the notations made during previous reviews, review the questions which have caused the students general difficulty. Present each question before the class, and clarify any points which will eliminate any misunderstanding. The normal time allotment for this review is one and one-half hours.



FINAL EXAMINATION

Do not permit the students to refer to any material while answering the questions in Part I of this examination. Display Wall Charts Nos. 1 and 2 before presenting Part II. The normal time allotment for these two parts is one and one-half hours, total.

Part III of the examination should be conducted in the laboratory. Provide each student with the necessary equipment. Refer to the Trouble-Shooting Supplement for the placement of troubles in the equipment. Do not place a rigid time limit on this part of the examination, but rate each student according to the time required to locate and correct each trouble. The normal time allotment for this part of the examination is two and one-half hours.

PART 1

1. What type of modulation is used in the transmitting set?
   a. Plate modulation.
   b. Grid modulation.
   c. Cathode modulation.

2. When the TUNE-OPERATE switch is set to the TUNE position, what is the effect on the plate voltage of the modulator tubes?
   a. The voltage is doubled.
   b. The voltage is halved.
   c. The voltage is not affected.
   d. The voltage drops to zero.

3. What is the function of the microphone transformer?
   a. The transformer provides a voltage loss to the grid circuit of the speech amplifier, and matches the low-impedance input circuit to the high-impedance grid circuit.
   b. The microphone transformer provides a voltage gain to the grid circuit of the speech amplifier, and matches the high-impedance input circuit to the low-impedance grid circuit.
   c. The microphone transformer provides a voltage gain to the grid circuit of the driver stage, and matches the low-impedance input circuit to the high-impedance grid circuit.
   d. The microphone transformer provides a voltage gain to the grid circuit of the speech amplifier, and matches the low-impedance input circuit to the high-impedance grid circuit.

4. The local speech input is attenuated by:
   a. A mismatch in the local microphone.
   b. A fixed series resistance.
   c. A variable series resistance.
   d. A fixed parallel resistance.

5. During normal transmitter operation the audio oscillator:
   a. Functions at all times, and its output is controlled by the keying relay.
   b. Is disabled when terminals 11 and 12 on the rear of the modulator panel are open-circuited.
   c. Is turned on and off from the remote operating position.

6. Why are high-vacuum tubes used in the power-supply circuits instead of mercury-vapor tubes?
   a. Because the voltage drop is more constant with variations in load current.
   b. Because there is less danger of arc back and faulty starting of the rectifier circuits in certain climates.
   c. Because high-vacuum tubes are usually used in rectifiers which are built to deliver high power outputs.

7. Three secondary windings are needed on the filament supply transformer in the power-supply bridge-type rectifier circuit because:
   a. All of the filaments are at the same d-c potential.
   b. All of the filaments are not at the same a-c potential.
   c. All of the filaments are not at the same d-c potential.

8. What are the functions of the power control circuits?

9. From what source do the microphone circuits obtain power?

10. What class of amplifier is employed in the speech-amplifier stage?

11. Does the type of speech input (local or remote) affect the amplitude of the audio signal reaching the driver stage?

12. What does the value of the plate series resistance in the audio-oscillator stage determine?

13. What is the purpose of the audio oscillator?

14. From what source does the keying relay obtain power?

15. What is the value of the input voltage to the power-supply circuits?

16. State the approximate values of the d-c voltages supplied by the power-supply circuits.

17. What are the values of the operating voltages for the signal-control and plate-control relays?

18. What circuits of the equipment can be energized with the POWER MAINS switch OFF (open position)?

19. What type of coupling is used between the intermediate power amplifier and the power amplifier?

20. What is the purpose of the 50-ohm resistors used in the cathode and filament-bias circuits of certain radio-frequency stages?

21. On Radio Transmitter BC-640-A, what meter is used to provide a rough indication of the modulation level?

22. What control is used to vary the modulation level?

23. On Radio Transmitter BC-640-B, what meter may be used to obtain a relative indication of the transmitter output?

24. Why is it necessary to set the TUNE-OPERATE switch to the TUNE position while tuning certain circuits of the transmitter?

25. When tuning the 2nd-tripler stage, why is it essential that the T2 dial be set within 15 dial divisions of the CO/T1 dial?

PART II

1. An ohmmeter connected between the cathode circuits of the speech-amplifier stage and ground shows an infinite-resistance reading. What component is probably defective?
   - a. Capacitor 31-14.
   - b. Capacitor 32-1.
   - c. Resistor 50.
   - d. Resistor 46-1.

2. A continuous 1000-cycle signal is heard in the transmitter output during voice operation. What component is probably defective?
   - a. Relay coil 42.
   - b. Resistor 48.
   - c. Capacitor 31-9.
   - d. Audio-oscillator tube VT94.

3. The transmitter is apparently operating normally, but no response is obtained on TRANSMITTER AVAILABLE signal lamp at the remote operating position. What is the probable cause of trouble?
   - a. Defective contacts on relay 7.
   - b. Relay coil 8 open.
   - c. Selenium-rectifier circuits.
   - d. Fuse 4-1.

4. What test point may be used to isolate trouble to the crystal oscillator?
   - a. 2.
   - b. G.
   - c. E4.
   - d. E1.

5. The crystal-oscillator tube is removed from its socket. An ohmmeter connected betwen pin numbers 2 and 7 on the tube socket shows an infinite-resistance reading. What component is probably defective?
   - a. Primary winding of transformer 196.
   - b. Secondary (3 and 4) winding of transformer 196.
   - c. Capacitor 161-2.
   - d. Tube filaments.

6. An indication of 25,000 ohms is observed when an ohmmeter is connected between the plate of the 1st tripler and ground, with the wiring harness removed from rear of chassis. What component is probably defective?
   - a. Capacitor 168-1.
   - b. Coil 179.
   - c. Capacitor 167.
   - d. Resistor 191-1.

7. If capacitor 173 were open, what would be the effect on the operation of the transmitter?
   - a. No effect.
   - b. Transmitter output weak.
   - c. Carrier could not be modulated.
   - d. Transmitter would fail because i.p.a. could not be neutralized.

8. If all meters on the amplifier panel indicate abnormally low reading, what is the most logical item to check before checking the various circuits?
   - a. Unbalanced amplifier tubes.
   - b. High-voltage breakdown in tube socket.
   - c. TUNE-OPERATE switch set to TUNE position.
   - d. Defective bleeder resistor 96.

9. On Radio Transmitter BC-640-B, an abnormal indication is observed at major test points 2 and 3. What group of circuits is the most logical to check first?
   - a. Audio-oscillator circuits.
   - b. D-c meter circuits.
   - c. Microphone circuits.

10. Capacitor 161-4 is shorted. List the test points needed to isolate the trouble.

PART III

The instructor will place six separate troubles in the equipment, one at a time. By means of visual inspection, operational check, checks at test points, and further voltage and resistance measurements, as required, localize, isolate, and locate each trouble and correct it. Restore the transmitter to its original condition.

REVIEW OF FINAL EXAMINATION

State each question and trouble-shooting problem in the Final Examination, and explain the answers to those questions which cause general difficulty. Permit the students to ask questions of their own. Allow classroom discussion on questions, within reasonable limits of time. The normal time allotment for this review is one hour.

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